Pipe and Lucerne Lakes Integrated Aquatic Vegetation Management Plan

May 2004

King County

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Cover Photos: Pipe and Lucerne Lakes 2003 and 2004, taken by Water and Land Resources Division Staff.

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The contractors who have been involved with the project over the years deserve special thanks for their expertise and diligence. Both AquaTechnex and Envirovision have worked on this project and will continue into the future to ensure that hydrilla disappears for good.

The cities of Maple Valley and Covington recognized the importance and urgency of this project and have been very cooperative with the state and county, supplying matching funds and support where necessary.

Finally, special thanks to the Pipe and Lucerne Lakes community for their dedication, understanding, and patience with the project to eradicate hydrilla. It has been a long road, but residents continue to support the need and importance of this project.

Although this document is retroactive, it is important to understand the benefits of a comprehensive document like this for the goal of eradicating and controlling noxious aquatic weeds. Presenting all options for possible control help the project managers stay fluid in their treatment options. Documents such as this one will also help future groups learn more about controlling and hopefully eradicating the noxious weeds that plague our water systems.

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EXECUTIVE SUMMARY

Hydrilla (*Hydrilla verticillata*) is considered one of the worst aquatic weeds in the country. It propagates through fragmentation, tubers, turions, and seeds; making it a difficult plant to control and eradicate. Hydrilla can degrade the ecological integrity of a water body in a few growing seasons. The plant can form dense stands that clog lakes, rivers, reservoirs, and irrigation canals and choke out native aquatic vegetation, altering the predator-prey relationships among fish and other aquatic animals. These mats can also decrease dissolved oxygen by inhibiting water mixing areas, increase the water temperature by absorbing sunlight, create mosquito breeding areas, and negatively affect recreational activities such as swimming, fishing, and boating. When the plant dies it becomes a food source for bacteria that consume the plant and use oxygen in the process, which reduces dissolved oxygen. The die-off of hydrilla also releases nutrients to the water that can cause algal growth and related water quality problems (Frodge, 2004).

Hydrilla is native to parts of Asia, Africa and Australia, and in the 1950's hydrilla was introduced to Florida through the aquarium trade. It has since spread north and west to Texas and California, throughout the southeastern states, and as far north as Maine in the east and Washington State in the west. There were apparently two different introductions of the plant because two different varieties, monoecious (having both male and female flowers on the same plant) and dioecious (all female flowers), are found in North America. The monoecious variety is the hydrilla variety found in the more northern locations. Dioecious hydrilla predominates in the southern United States. The monoecious variety was found in Washington State in 1994 in Pipe and Lucerne Lakes in King County. DNA analysis has shown that the hydrilla in Washington is likely of Korean origin.

Pipe and Lucerne lakes are located in the Green – Duwamish River watershed in King County, Washington. Although they are named separately, Pipe and Lucerne are connected hydrologically by a small channel and share similar water quality and ecological characteristics. In 1994, hydrilla was found in both lakes. To date this is the only known infestation of hydrilla in the Pacific Northwest. Because further spread of the hydrilla could cause widespread ecological damage and demand millions of dollars in control costs, the Department of Ecology (Ecology) and King County took immediate action to begin the eradication process in the lakes. A private contractor applied both liquid and pellet forms of the aquatic herbicide Sonar® (active ingredient fluridone) to the lakes from 1995 to 2000. Plant densities decreased substantially during these years, but in 2001 the Ninth Circuit Court of Appeals ruled on the Talent decision stating that pesticides including herbicides could not be applied in aquatic systems without a National Pollutant Discharge Elimination System (NPDES) permit. Subsequently herbicide applications were halted on the lakes and during 2001 – 2002 diver hand-pulling was used as the treatment method. This allowed any undetected hydrilla to propagate and set tubers and turions for two growing seasons. Herbicide treatments resumed in 2003 after healthy plants were found in the lakes in the fall of 2002.

Although other noxious weeds grow in the lakes, including both fragrant water lily and yellow flag iris, hydrilla is the plant of highest priority. It is listed as a Class A Noxious weed on the Washington State Noxious Weed List. Eradication of this plant is critical to preserving Pipe and Lucerne Lakes habitat, aesthetic beauty and recreational uses, as well as preventing it from spreading to other aquatic systems in the region. If hydrilla spreads, it could result in costs to the state of millions of dollars in control work. The state of Florida spends upwards of $15 million a year attempting to control hydrilla.

Washington might experience similar annual costs if hydrilla is not eradicated from Pipe and Lucerne Lakes.

King County has managed the project to eradicate hydrilla from the two lakes since discovery with funding provided by Ecology. The County and state worked with and continue to work with leading aquatic weed experts to ensure the best available science is being used to tackle the infestation. The community is kept updated by flyers and public meetings detailing current treatment plans and progress.

Currently the strategy is to continue a combination of herbicide treatments and diver assessment and hand-pulling until hydrilla is no longer found. Assessment will continue until hydrilla has not been found for three years in a row, when it will be considered eradicated. If hydrilla is detected at any time during the three-year post-assessment period, treatments will resume until hydrilla is no longer detected. Assessment will then continue for a further five years. This scenario is consistent with California's strategy for hydrilla eradication. California has successfully eradicated numerous separate hydrilla infestations. The plan will remain flexible as we learn more from our experience and the experience of others working on hydrilla eradication.

An Integrated Aquatic Vegetation Management Plan (IAVMP) is a planning document developed to ensure that the state and local governments and the community have considered the best available information about the waterbody and the watershed. This document will help select the most effective control efforts and meet all permitting and regulatory requirements. This plan includes information on the lake and watershed characteristics, details of the hydrilla problem at Lakes Pipe and Lucerne, discussion of control alternatives, estimated costs and recommendations for ongoing control of hydrilla threatening Pipe and Lucerne Lakes.

PROBLEM STATEMENT

Pipe and Lucerne Lakes straddle two different municipalities in King County, with Lake Lucerne and the eastern section of Pipe Lake located in the city of Maple Valley and the western section of Pipe Lake located in the city of Covington. Pipe and Lucerne Lakes, along with neighboring lakes, Shadow and Wilderness, are located in the Jenkins Creek sub-basin of the Green–Duwamish River Watershed. The Green–Duwamish River Watershed provides excellent habitat for several fish species, including anadromous salmonids. Pipe and Lucerne Lakes are mostly groundwater and surface water fed; an outlet leading from Lucerne runs part of the year and feeds into Jenkins Creek. Private property surrounds both lakes, providing limited public access, but allowing local recreational opportunities through community beach clubs, such as the Cherokee Bay Community Club. Residents along the lakeshore are very proud of their setting and the recreational activities that the lakes provide them.

In 1994, a large population of *Hydrilla verticillata* (hydrilla) was found growing in Pipe and Lucerne Lakes. The shallow shoreline area provides excellent habitat for aquatic plants, and hydrilla was colonizing much of the near shore aquatic habitat, crowding out native plant species. The discovery of hydrilla in Pipe and Lucerne Lakes has been the only infestation found to date in the state and region. Its eradication is a major priority for King County and Washington State.

Hydrilla is listed in Washington State as a Class A noxious weed in Washington State Administrative Code (WAC 16-750), which necessitates that an eradication plan be implemented immediately. This noxious aquatic weed is highly prolific, spreading through fragmentation, tubers, turions, and seeds, thus complicating eradication efforts. Hydrilla can spread to other lakes by fragments attached to boat motors and trailers. Other lakes in the county and eventually the state face potential threats of hydrilla infestation if it is left untreated. The lake is private, so movement of boats between Pipe/ Lucerne and other area lakes is minimal, lessening the risk of spread between lakes for the immediate future.

Hydrilla is the only submersed noxious weed currently found in the lakes. Other Class C noxious weeds occur in the lake system, including fragrant water lily (*Nymphaea odorata*) and yellow flag iris (*Iris pseudacorus*). Eurasian water Milfoil (*Myriophyllum spicatum*), a Class B weed, was found in 1994, but has been eradicated as a side benefit of hydrilla management activities. All of these species are considered noxious weeds as listed in the Washington State Administrative Code (WAC 16-750). Hydrilla is the number one priority of this project because of the legal mandate to eradicate the infestation immediately; the Class C weeds are of lesser concern and not addressed in this IAVMP. The native aquatic plants in the system provide important benefits to the aquatic system, and their densities are not a management issue at this time. Removing the hydrilla will halt the degradation of the system and allow a dynamic natural equilibrium to be established.

Hydrilla is mainly found in the near shore zone, the most utilized and valued portion of the lake by lake residents and visitors.

Hydrilla can affect beneficial uses of waterbodies in many ways, including:

1. Pose a safety hazard to swimmers and boaters by entanglement;

2. Snag fishing lines and hooks, eventually preventing shoreline fishing;

3. Clog intakes for drinking water, irrigation, and/or power generation;

4. Crowd out native plants, creating a monoculture lacking in biodiversity;

5. Significantly reduce fish and wildlife habitat, thereby weakening the local ecosystem as well as degrading wildlife and wildlife viewing opportunities;

6. Pose a major threat to adjoining ecosystems.

In Pipe and Lucerne Lakes, all of the above effects may be observed. Even though the lakes are not used for drinking water or power generation, some residents hold state permits to withdraw water for irrigation.

Eradication is the goal of the project, and work will be continued on the lake until it is considered complete. If hydrilla was left unchecked, the lake would soon become heavily infested, severely degrading the lake ecosystem and providing a potential source that could spread throughout King County and the state.

PROJECT HISTORY

1995 - 2001

Immediately following the discovery of hydrilla in Pipe and Lucerne Lakes Ecology and the State Noxious Weed Control Board mandated quick action. At this time the lakes were under King County's jurisdiction, making the county responsible for treatment. A panel of national hydrilla control experts was formed and these scientists and managers provided direction to Ecology and King County to guide the project. The panel recommended treating the lake with the systemic herbicide fluridone (Sonar). Because herbicides do not affect tubers, it was anticipated that these herbicide treatments would occur for several years.

In the summer of 1995, the county hired Resource Management Inc. (RMI) to apply Sonar AS (liquid formulation) to kill all the existing hydrilla plants. In accordance with treatment protocols, RMI maintained herbicide levels between 10 to 20 ppb in the lakes over eight weeks. The hydrilla responded well to the use of the herbicide with up to 99 percent or greater of the plants killed. However, as expected, a substantial viable tuber bank remained in the sediments. Current research suggests that tubers can be viable for up to ten years and are not necessarily affected by herbicides. Also not all tubers germinate in any one year. Therefore, as anticipated, one herbicide treatment was not sufficient to completely eradicate hydrilla and whole lake treatments using the herbicide Sonar were continued from 1995 to 2000. These actions greatly reduced the weed concentrations throughout the lakes, although small populations of hydrilla continued to germinate each spring from tubers.

Herbicide treatments were curtailed during the summer of 2001 because of a 9th Circuit Court decision. This Court decision was the result of a lawsuit filed in Oregon under the Clean Water Act (CWA) that called into question whether aquatic pesticides should be considered pollutants. The Court ruled that aquatic pesticides could be considered pollution and required that any pesticide application to waters of the United States be made under a National Pollution Discharge Elimination System (NPDES) permit. This resulted in Washington's Attorney General's Office interpreting the decision to mean that NPDES permits were required for all pesticide applications to waters of the state. It took Ecology a year to develop these permits and during this time, state funding was not allowed to be used for pesticide application. During this time SCUBA divers surveyed the littoral zones of Pipe and Lucerne Lakes for hydrilla; hand-pulling it as it was found (Waterline, 2001).

2002

By the summer of 2002, Ecology had developed NPDES permits for aquatic herbicides. However, King County chose to continue with the hand-pulling strategy in 2002 based on a perception of hand-pulling success in 2001. In the fall of 2002 after extensive hand-pulling efforts during the summer, a large regrowth of hydrilla was discovered and spot treated with Aquathol Super K (active ingredient Endothall) granular herbicide. The significance of finding hydrilla meant that divers were missing plants during the hand-pulling efforts. Missed plants were setting long-lived tubers, which would prolong the eradication effort. Clearly the hand-pulling only strategy alone was not effective as an eradication method.

2003

Since hand-pulling was proven ineffective as an eradication method other techniques of hydrilla control were considered. The panel of scientific experts was consulted and various techniques were evaluated. Using Grass Carp as a biological control was initially considered for use in 2003 or 2004 as a control technique used in conjunction with herbicides. However, it was decided to base a new herbicide application strategy on the successful hydrilla eradication experiences of the State of California. One of the techniques that California uses is to maintain low levels of fluridone in the hydrilla-infested lakes during the entire growing season. This treatment scenario, along with diver survey, continues for several years until no hydrilla is found in the treated areas for three consecutive years. At this point, hydrilla is considered to be eradicated from the water body. This technique had also been used in Pipe and Lucerne Lakes in prior to 2002, but eradication had not been achieved. It is possible that the liquid formulation of fluridone did not effectively treat plants below the thermocline. Temperature gradients can prevent liquid herbicides from mixing below the temperature layers. The new strategy was to use a new granular formulation of fluridone that would allow herbicide to be applied directly to the plants and nearby areas. Because the granules sink to the bottom, fluridone is released below the thermocline.

To monitor the success of this revised hydrilla eradication strategy in Pipe and Lucerne Lakes, King County decided to conduct the herbicide treatments and the snorkeling surveys using their own staff, hiring a consultant only to perform the diver surveys. Prior to 2003, the County relied on contractor and consultants to perform these functions. In 2003, the County obtained an NPDES permit and treated the lakes with Sonar PR, a slow release pelleted formulation of fluridone. The goal for summer 2003 was to maintain a herbicide level of 5 ppb in both lakes throughout the summer. Hydrilla is particularly susceptible to fluridone and this concentration was considered to be sufficient to achieve 100 percent control of the newly germinated plants. Maintaining this concentration in the lakes required several applications of herbicide to the lakes over the course of the summer.

Prior to the initial herbicide treatment, and every 14 days thereafter, water samples were taken to measure levels of fluridone in the water column (Appendix B). Fluridone concentrations were measured using an immuno-assay method of detection called the FasTEST. Measuring fluridone water concentration helped the County to determine the timing and amount of herbicide that was applied throughout the summer. In conjunction with the herbicide treatments, both snorkel and SCUBA diver surveys were performed to survey the littoral zone extensively. If divers found hydrilla during the survey and it was feasible, they would hand pull the hydrilla plants. Areas treated with Sonar were adjusted through the summer as new locations of hydrilla were found. A report that summarizes the 2003 hydrilla eradication project can be seen at http://dnr.metrokc.gov/wlr/waterres/smlakes/.

MANAGEMENT GOALS

The overarching management goal is to eradicate *Hydrilla verticillata* from Pipe and Lucerne Lakes, preventing the spread of the weed to other lakes in King County and the state. This project will also allow native plant and animal communities to thrive, maintain acceptable water quality conditions, and preserve the recreational opportunities provided by the lakes.

There are four main strategies to ensure success in meeting this goal:

1. Use the best available science to identify and understand likely effects of management actions on aquatic and terrestrial ecosystems prior to implementation;

2. Review the effectiveness of management actions;

3. Adjust the management strategy as necessary to achieve the overall goal.

4. Involve the community in the management process;

Specific details related to the implementation of management objectives are covered in subsequent sections of this plan.

COMMUNITY AND RESPONSE

This project was initiated by the state, and eradication began immediately because of the perceived threat posed by hydrilla. Because of the laws in place for Class A noxious weeds, there is no choice of outcomes in the project: hydrilla must be eradicated and flexibility only occurs in how to meet the goal. To include the community and receive citizen input, public meetings have been held each treatment season from 1995 and thereafter. This provides a forum that allows the public to voice concerns or make comments about the chosen treatment method. Before 2003, a meeting occurred once a year to inform the public of the treatment methods to be used. In 2003, a post-treatment meeting was also held to discuss the treatment results. Two meetings a year are proposed for the future.

Because of the longevity of the control project, most of the area residents are aware of the problem, recognize the seriousness of the infestation and support the state and county's actions each treatment season. Although 1,300 notices are sent out each year advertising the meetings, less than 10 people have attended the public meetings in recent years (Appendix C).

During the summer, County staff has direct contact with many of the lakeside residents and has heard few complaints. When complaints are voiced, the most common complaint is the temporary inability to use the lake water for irrigation because of the herbicide concentrations. Prior to each treatment season, every residence in the watershed receives a notice with the herbicide treatment dates. To fulfill NPDES permitting requirements, King County posts herbicide spray notices on each parcel of land around the lake within 24 hours of treatment. Community swim areas were also posted with 2' by 3' signs to clearly alert any swimmers of the herbicide treatment. Sonar PR® has no restrictions for irrigation if the concentration in the water column is less than 10 parts per billion (ppb). Pipe and Lucerne Lakes have target concentrations of five ppb so there are no irrigation restrictions, however, the notices state that use of lake water for irrigation could injure desirable plants and that residents should use caution. Also fluridone concentrations, particularly in Lucerne Lake, were sometimes higher than 10 ppb in 2003.

There was one herbicide-related complaint in the summer of 2003. A woman called to complain of her and her children's itchy eyes and rash the day of the first Sonar PR® treatment. The County asked that she document her ailments and visits to the doctor in a letter to the county, but nothing was submitted. The County immediately took a water sample from the area and had it tested for fluridone. The fluridone concentrations were less than the target concentration of 5 ppb. To ensure there were no other herbicide related complaints the County posted notices at the swim beaches around the lake requesting that individuals contact the county if they had experienced negative reactions to the treatment. There were no responses to the notice.

In other interactions with the public, the feedback on the treatment has been positive. Residents are appreciative of the work that is being done on the lake and have voiced no major complaints.

WATERSHED AND WATERBODY CHARACTERISTICS

Watershed Characteristics

Pipe and Lucerne Lakes are within the cities of Maple Valley and Covington, located in south King County, Washington (Fig. 1). State resource agencies frequently use a system called Watershed Resource Inventory Areas (WRIA) to refer to the state's major watershed basins. Pipe and Lucerne are located in WRIA 9, the Green-Duwamish watershed. The lakes are located in the Soos Creek sub-basin of the Middle Green-Duwamish Watershed. Soos Creek sub-basin is approximately 44,800 acres and receives a mean annual rainfall of 970mm (Seattle-Tacoma Airport 50-year average). A nearly continuous low-permeability layer of Vashon till covers the Soos Creek sub-basin. It is breached only locally, limiting the rapid recharge of the underlying aquifers. There are granular deposits of Vashon-age advance outwash or older Auburn gravel, directly under much of the till. They are a locally valuable water source because of their shallow depth, moderate thickness, and high (though variable) permeability. The Vashon-age recessional outwash, common in this basin, proved a direct hydraulic connection between surface water and the shallow aquifer (King County 1990).

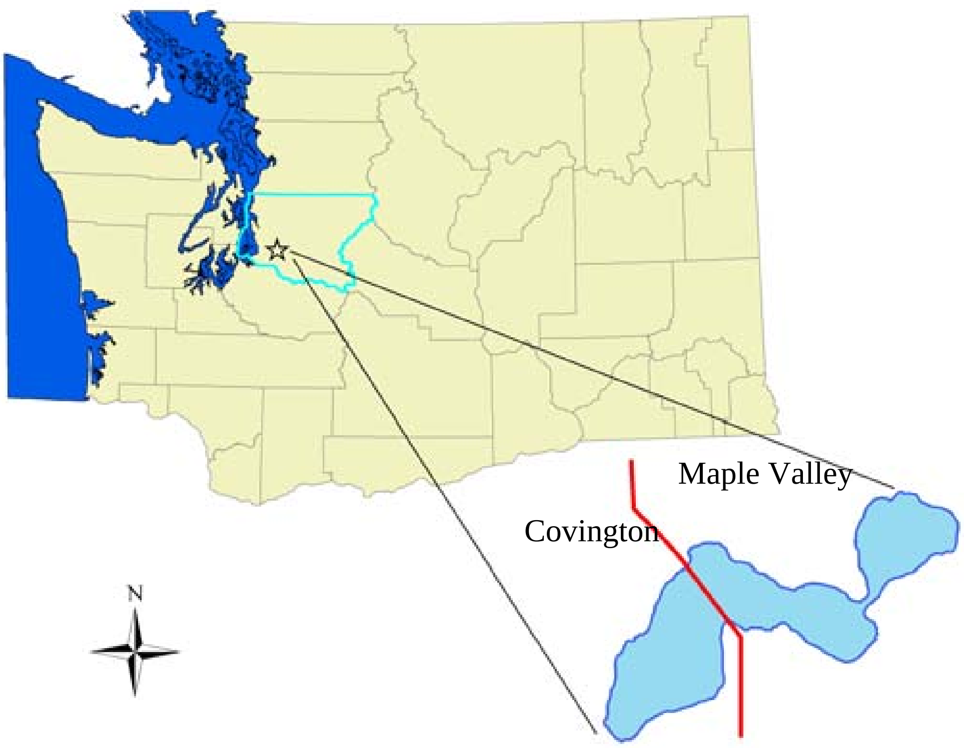

Figure 1: Location of Pipe and Lucerne Lakes

The Soos Creek system consists of mainstem Big Soos Creek and some 25 tributaries, including Jenkins Creek, which drains Pipe and Lucerne Lakes. Tributary 0090 flows from Lake Lucerne at its eastern tip and flows 5150 feet to join Jenkins Creek which flows into Soos Creek and then into the Green River. The areas around these lakes are currently urbanizing, with some higher-density residential development occurring in the central basin. Jenkins Creek, its tributaries, and related wetlands are considered intact, providing diverse and abundant aquatic habitat. In 1985 land cover such as pasture and grass, forests, and wetlands predominantly bordered the larger stream system. By 1990 it was predicted that in the future the majority of the watershed feeding larger stream system would change to a predominantly single family, developed land use (King County, 1990). This rapid development contributes to many problems in the sub-basin: flooding, non-point source pollution, raised bacteria counts, and higher water temperatures.

Pipe and Lucerne Lakes constitute approximately 408 acres (0.9%) of the Soos Creek sub-basin. Pipe and Lucerne Lakes are located at 540 feet above sea level; the surrounding geography is slightly rolling. The highest points in the watershed are located to the north and south of the lake, but the highest part is at 600 feet, only 60 feet higher than the lakes. These slight slopes channel the surface water into the lakes. Water enters Pipe and Lucerne Lakes through groundwater seeps, direct precipitation onto the lake, and stormwater runoff from the surrounding watershed (King County 1990).

Currently there are 143 single-family residences lining the lakes. There is one large tract (38 acres) of land belonging to the First Presbyterian Church from Tacoma, used for a summer camp. This is located in the western end of Pipe Lake and has about 800 feet of natural shoreline. There are also three private swim beaches for community members: two are located on the north and southwest shores of the lake, and the third is located on the southeastern shore of Pipe Lake. There are no community properties on Lake Lucerne.

Waterbody Characteristics

Pipe and Lucerne Lakes together make a 68-acre lake located in southern King County. Pipe Lake has a mean depth of 27 feet and a maximum depth of 65 feet, with an estimated lake volume of 1,500 acre-ft. Lake Lucerne is a 16-acre lake, connected to Pipe Lake by a small channel. Lucerne has a mean depth of 18 feet and a maximum depth of 37 feet, with an estimated lake volume of 310 acre-feet (Bortleson et al 1985). Combined, Pipe and Lucerne Lakes have 12,875 feet (2.4 miles) of shoreline. There are no visible surface inflows into either lake but there is an intermittent outflow from Lucerne on the eastern shoreline.

Water Quality

King County has run a volunteer monitoring program since the 1980's to collect long-term records of water quality for the region's small lakes. The volunteers from Pipe and Lucerne Lakes started collecting samples in the 1980's. The data record for Pipe and Lucerne Lakes is largely complete with data missing between 1989 to 1992.

Lakes can be classified by measurements of potential and actual biological activity, also known as "trophic state." Lakes with high concentration of nutrients and algae, generally accompanied by low water transparencies, are termed eutrophic or highly productive. Lakes with low concentrations of nutrients and algae, most often accompanied by high transparencies, are categorized as oligotrophic or low in productivity. Lakes intermediate between eutrophic and oligotrophic are termed mesotrophic. A commonly used index of water quality for lakes is the Trophic State index (TSI) originally developed by Robert Carlson (1977), which separates lakes into the three categories by scoring water clarity, and concentrations of both phosphorus and chlorophyll *a*, relating them to a scale based on phytoplankton biovolume. Lakes can be naturally eutrophic, mesotrophic, or oligotrophic based on the inherent character and stability of the surrounding watershed. Eutrophication or the increase in a lake's biological activity over time is a process that occurs naturally in some lakes and may be accelerated in others by human activities (King County 2003).

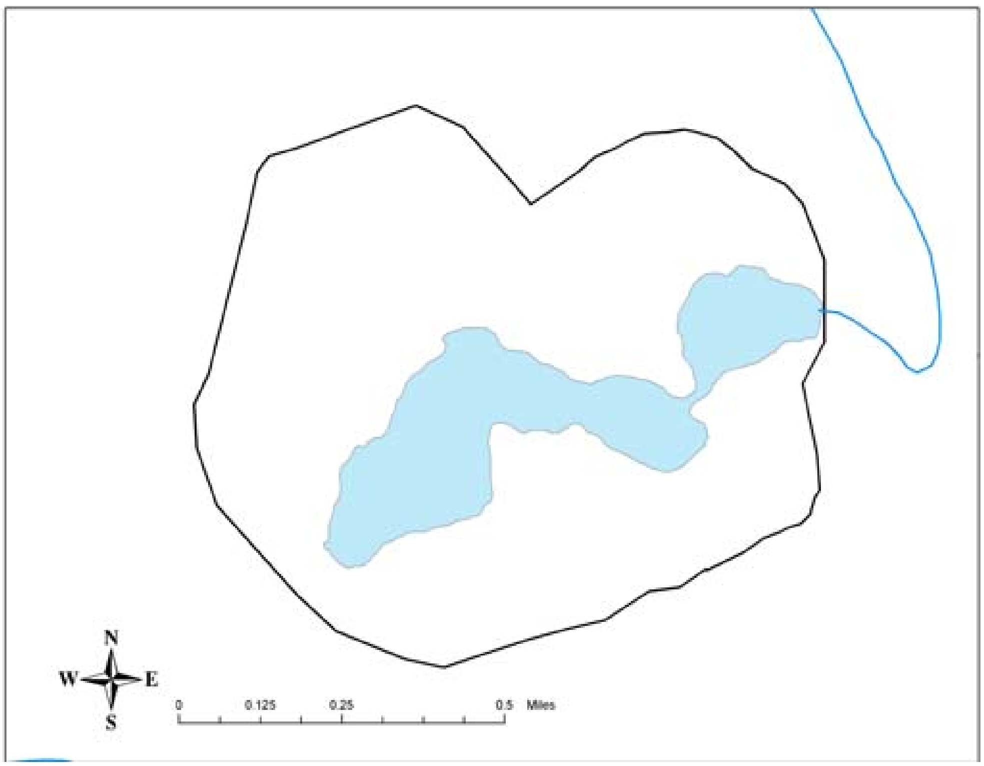

Figure 2: Pipe and Lucerne Lakes watershed and outflows

Pipe and Lucerne Lakes' productivity are both considered oligotrophic (low), bordering on mesotrophic (moderate), characterized by the high water clarity and low concentrations of chlorophyll *a* and total phosphorus. Data from the 16 year record 1985 to 2000 are summarized in Table 1, taken from King County Lake Water Quality: A Trend Report on King County Small Lakes (November 2001).

Table 1: Average Values for Select Trophic Parameters at Pipe Lake

Year	No. Samples	Secchi (m)	Chl a* (ug/L)	TP *	TSI* Secchi	TSI* Chl a	TSI* TP	TSI Average
1985	12	5.7	1.8	7	35	36	33	35
1986	12	5.1	2.2	9	37	38	36	37
1987	12	5.2	1.7	10	36	36	38	36
1988	12	5.1	1.4	9	37	34	35	35
1989	--	--	--	--	--	--	--	--
1990	--	--	--	--	--	--	--	--
1991	--	--	--	--	--	--	--	--
1992	--	--	--	--	--	--	--	--
1993	11	4.9	2.1	11	37	38	38	38
1994	11	5	2.3	15	37	39	43	40
1995	10	4.7	3	13	38	41	41	40
1996	12	4.4	3	12	39	41	41	40
1997	12	4.3	2	11	39	38	38	38
1998	11	5	1.5	9	37	35	36	36
1999	10	4.5	2.8	11	38	41	39	39
2000	11	3.9	2.1	10	10	38	37	38

Table 2: Average Values for Select Trophic Parameters at Lake Lucerne

Year	No. Samples	Secchi (m)	Chl a* (ug/L)	TP *	TSI* Secchi	TSI* Chl a	TSI* TP	TSI Average
1985	8	4.4	1.5	9	39	35	36	36
1986	11	5.8	2.1	8	35	38	34	35
1987	12	5.7	2	10	35	37	37	36
1988	16	5.1	2	13	37	37	41	38
1989	--	--	--	--	--	--	--	--
1990	--	--	--	--	--	--	--	--
1991	--	--	--	--	--	--	--	--
1992	--	--	--	--	--	--	--	--
1993	11	4.3	2.4	14	39	39	43	40
1994	10	4.9	3.5	17	37	43	45	41
1995	7	4.2	3.7	13	39	43	41	41
1996	7	5.3	1.6	13	36	35	41	37
1997	12	4.2	2.2	12	39	38	40	39
1998	13	5.6	1.2	9	35	32	36	34
1999	13	4.2	3.1	12	39	42	40	40
2000	12	4.1	2.7	10	40	40	37	39

Pipe

- Water clarity (Secchi depth) ranged from 3.9 – 5.7 meters (May – October average)
- Total phosphorus ranged from 9 – 15 µg/L (May – October average).
- Chlorophyll *a* ranged from 1.4 – 3.0 µg/L (May – October average), but most years were well below 3.0 µg/L.
- TSI Secchi ranged from 35 – 40.
- TSI Chlorophyll *a* ranged from 34 – 41µg/L.
- TSI Total phosphorus ranged from 33 – 43 µg/L.
- TSI annual average ranged from 35 – 40.

Lucerne

- Water clarity (Secchi depth) ranged from 4.1 – 5.8 meters (May – October average).
- Total phosphorus ranged from 8 – 17 µg/L (May – October average).
- Chlorophyll *a* ranged from 1.2 – 3.7 µg/L (May – October average).
- TSI Secchi ranged from 35 – 40.
- TSI Chlorophyll *a* ranged from 35 – 43 µg/L.
- TSI Total phosphorus ranged from 34 – 45 µg/L.
- TSI annual average ranged from 34 – 41.

Trend analyses were performed on both lakes to evaluate whether statistically significant changes in water quality have occurred. The non-parametric Mann-Kendall's test for trend at the 95 percent confidence interval (α = 0.05 significance level) was used. In Pipe and Lucerne a significant downward trend was found in Secchi depth, suggesting a decline in water clarity has occurred since 1985. A similar trend was not seen for Chlorophyll *a* indicating no increases in algal production, which suggests that the decline in secchi clarity could be due to sediment resuspension from the fluridone removal of hydrilla. However, this is not accompanied by statistically significant trends in phosphorus. Overall the water quality in the lakes is very good, partially because groundwater is a primary source of water. Stewardship by lakeside residents will be very important to ensure ongoing erosion and nutrient control measures take place as land is developed in the watershed or local shoreline alteration occurs.

Fish and Wildlife Communities

Pipe and Lucerne Lakes and their surrounding habitats support a variety of fish, birds, and animals by providing nesting, forage, and cover. According to Andy Applebee at the Washington State Department of Fish and Wildlife (WDFW), in the 1950's Pipe and Lucerne were both known to have rainbow trout (*Oncorhynchus mykiss*), bluegill (*Lepomis macrochirus*), and perch (*Perca flavescens*) (A. Appleby, pers. comm. 2003). In snorkel and diver plant surveys performed in the summer of 2003, there were four dominant resident fish observed, largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), and smallmouth bass (*Micropterus dolomieui*). Since Pipe and Lucerne are private lakes, not opened to the general public for recreational opportunities, WDFW does not stock the lakes. Citizens must pay for the stocking of the lakes themselves. Most of the anglers are residents in the area who come to use the boat launch.

Katie Messick of the King County Lake Stewardship Program formulated a hypothetical list of birds and animals based on lakes nearby. This list includes eight species of regulatory significance including the great blue heron, wood duck, bald eagle, osprey, common goldeneye, hooded merganser, and bufflehead. Table 3 lists birds that are likely found using the Pipe and Lucerne lakes for food and habitat.

Table 3: Checklist of birds probable on Pipe and Lucerne Lakes in order by family

Probable Birds in Bold
Other Possible Birds in Italics

LOON

- ☐ *Common Loon SS*

GREBES

- ☐ **Pied-billed Grebe**
- ☐ *Horned Grebe*
- ☐ *Western Grebe SC*

CORMORANT

- ☐ **Double-crested Cormorant**

WADERS

- ☐ **Great Blue Heron** KCS
- ☐ *Green Heron*

WATERFOWL

- ☐ *Trumpeter Swan*
- ☐ *Greater White-fronted Goose*
- ☐ *Snow Goose*
- ☐ **Canada Goose**
- ☐ *Wood Duck*
- ☐ *Green-winged Teal*
- ☐ **Mallard**
- ☐ *Northern Pintail*
- ☐ *Blue-winged Teal*
- ☐ *Cinnamon Teal*
- ☐ **Northern Shoveler**
- ☐ *Eurasian Wigeon*
- ☐ **American Wigeon**
- ☐ *Canvasback*
- ☐ *Redhead*
- ☐ **Ring-necked Duck**
- ☐ *Greater Scaup*
- ☐ *Lesser Scaup*
- ☐ *Common Goldeneye*
- ☐ *Barrow's Goldeneye*
- ☐ **Bufflehead**
- ☐ **Hooded Merganser**
- ☐ *Common Merganser*
- ☐ *Red-breasted Merganser*
- ☐ *Ruddy Duck*

RAPTORS

- ☐ *Osprey* KCS
- ☐ **Bald Eagle** ST, FT

RAILS

- ☐ *Virginia Rail*
- ☐ *Sora*
- ☐ **American Coot**

SHOREBIRDS

- ☐ **Killdeer**
- ☐ *Spotted Sandpiper*
- ☐ *Common Snipe*

GULLS

- ☐ **Mew Gull**
- ☐ **Ring-billed Gull**
- ☐ **Glaucous-winged Gull**

SWIFTS

- ☐ *Black Swift*
- ☐ *Vaux's Swift SC*

KINGFISHER

- ☐ **Belted Kingfisher**

SWALLOWS

- ☐ *Purple Martin SC*
- ☐ **Tree Swallow**
- ☐ **Violet-green Swallow**
- ☐ **Northern Rough-winged**
- ☐ *Cliff Swallow*
- ☐ **Barn Swallow**

WRENS

- ☐ *Marsh Wren*

WARBLERS

- ☐ *Common Yellowthroat*

BLACKBIRDS

- ☐ **Red-winged Blackbird**

NOTES

SC = state candidate

SS = state sensitive

ST = state threatened

FT = federally threatened

KCS = King County Comprehensive Plan Shall be Protected

The mixed forest and wetland plant communities around the lakes provide non-breeding habitat for a few Puget Sound lowland amphibian species, such as the Pacific chorus frog (*Pseudacris regilla*). Unfortunately, the non-native bullfrog (*Rana catesbeiana*) is also quite common at Pipe and Lucerne Lakes, and they can have a negative impact on our native amphibians through direct predation (Richter & Azous, 2001a). Beaver (*Castor canadensis*) are frequently seen and heard around the lake, whereas river otter (*Lutra canadensis*) are considered a rare treat to observe. Other mammals expected to make use of the lake and adjacent forested areas include: opossum (*didelphus marsupialis)*, bats such as the little brown bat *(myotis lucifugus)*, mountain beaver (*aplodontia rufa*,), douglas squirrel (*tamias douglasii*), muskrat (*ondatra zibethica*), coyote (*canis latrans*), and raccoon (*procyon lotor*).

The Washington Natural Heritage Program (WNHP) performed a search of their Natural Heritage Information System database for rare plant species, select rare animal species, and high quality wetland and terrestrial ecosystems in the vicinity of Pipe and Lucerne Lakes (Moody, 2004). This search did not find any endangered, threatened, or sensitive plant species recorded for the area.

Beneficial and Recreational Uses

Pipe and Lucerne Lakes support a variety of uses to humans. Recreational activities include swimming, fishing, boating (non-combustion motors only), bird watching, and wildlife viewing. Residents access the lake for these activities from the small private docks around the lake associated with the residential parcels. Private beach clubs exist along the shores of Pipe Lake, which provide access, mainly in the form of swimming to area residents. There are no public beaches or boat launches in either lake. There is one boat launch that belongs to the largest private beach club, the Cherokee Bay Club, in the eastern end of the lake (Fig.3).

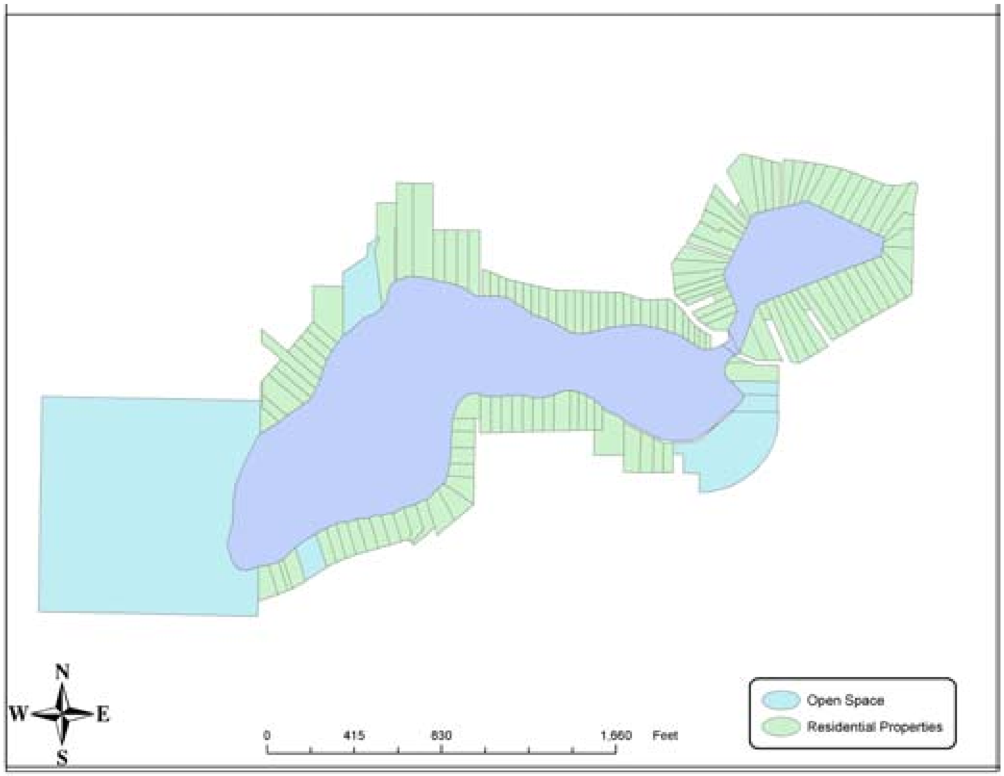

Figure 3: Property uses along Pipe and Lucerne Lakes

No internal combustion engines are allowed on the lake (KCC 12.44.330). Consequently there are no activities such as water skiing or jet skiing. One outcome of this ban is that something of the natural character and integrity of the system has been preserved. Also, the system is spared potential pollution from petroleum releases and noise pollution.

Characterization of Aquatic Plants in Lakes Pipe and Lucerne

The most recent aquatic plant surveys were performed in the summer of 2003. During the July hydrilla surveys, contracted SCUBA divers also noted the other aquatic plants in the lakes. Table 4 lists the species the SCUBA divers identified in both lakes at the end of June. It should be noted that the density and distributions of the plants do change through the course of the growing season.

Prior to the 2003 survey, the last time the lakes were comprehensively surveyed was in 1994. King County's Lake Stewardship Program surveyed 36 lakes in the county (King County, 1996) using two-person crews plus a volunteer when available. Surveyors used Global Positioning System (GPS) to establish shoreline sections between two fixed points. Each shoreline section was characterized by community type, species present, percent cover of community type, and relative species density within a community type. Community types were defined as emergent, floating, or submergent (Figure 4).

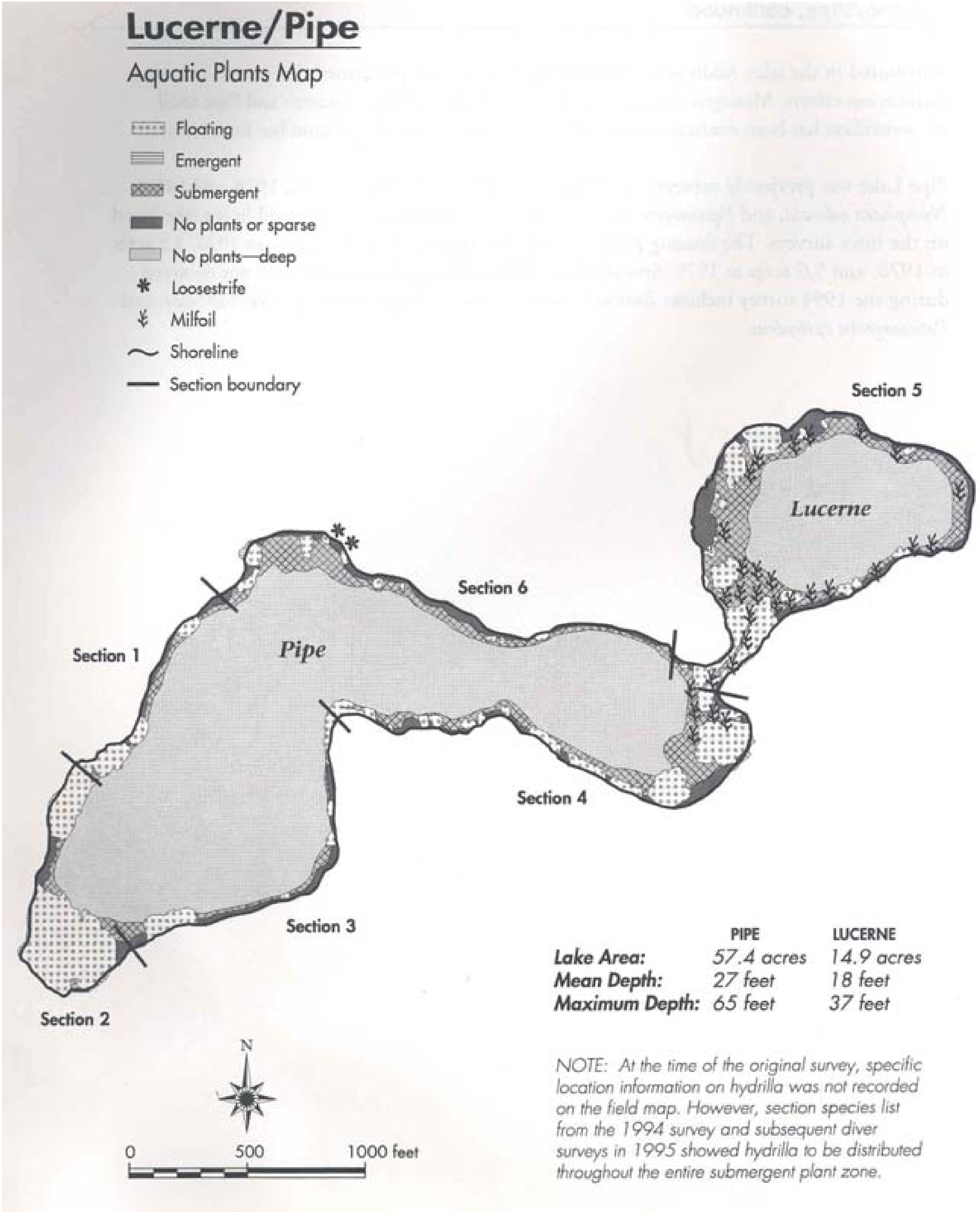

Figure 4: 1996 Aquatic Plant Map

Nineteen plant species were identified at Pipe and Lucerne Lakes, including one floating type, ten submergent types, and eight emergent types. Floating plants are rooted in the sediment and send leaves to the lake surface. Submergent plants are either freely floating or are rooted in the lake bottom but grow within the water column. Emergent plants are rooted in the sediment at the edge of the lake, but have stems and leaves that grow above the water surface.

Pipe and Lucerne were also surveyed almost every year in the late 1970's (1976, 1978, and 1979). The dominant species in these surveys included *Chara, Elodea canandensis, Fontinalis sp., Isoetes, Najas flexilis, Nitella sp., Nuphar variegatum, Nymphaea odorata, Potamogeton amplifolius, Potamogeton berchtoldii* (now *pusillus*), *Potamogeton epihydrus*, and *Utricularia vulgaris*.

In 1978, Pipe Lake was drawn down to facilitate the installation of sewer lines. While the lake level was lower, residents removed a majority of the near shore plants (mostly lilies) and covered the near shore with gravel or weed barriers with the intention of limiting future water lily growth. It was discovered that a "crystal like" herbicide had previously been used on lilies in Pipe Lake but the name is unknown and lake residents deemed it "ineffective". It is thought that it could possibly have been Aquacide, which is a granular from of 2,4-D. This particular herbicide formulation is ineffective on water lilies. The 1979 survey noted that the gravel and weed barriers were not a complete success and in many of the areas lilies were growing again.

Noxious Aquatic Weeds in Lakes Pipe and Lucerne

The term "noxious weed" refers to those non-native plants that are legally defined by Washington's Noxious Weed Control Law (RCW 17.10) as highly destructive, competitive, or difficult to control once established. Noxious weeds have usually been introduced accidentally as contaminant or sometimes are deliberately planted as ornamentals. Non-native plants often do not have natural predators (i.e. herbivores, pathogens) or strong competitors to control their numbers as they may have had in their home range. WAC 16-750 sets out three classes (A, B, C) of noxious weeds based on their distribution and perceived threat throughout the state, each class having different control requirements. County Weed Boards are given some discretion as to setting control priorities for Class B and C weeds.

Table 4 shows the plant species found in the 2003 plant survey, including three listed noxious weed species: most importantly hydrilla (*Hydrilla verticillata*), fragrant water lily (*Nymphaea odorata*), and yellow flag iris (*Iris pseudacorus*). Hydrilla will be the focus of the management effort on Pipe and Lucerne. However, there is a potential of fragrant water lilies being incidentally controlled as well. Hydrilla is a Class A noxious weed; Class A means it is the State's highest priority for eradication. Fragrant water lily and yellow flag iris are Class C Noxious Weeds; Class C weeds are generally not required by law to be controlled and contained, but counties may designate a Class C weed for control in their county or in certain areas of their county. Neither yellow iris nor fragrant water lilies are required to be controlled in King County.

Table 4: Aquatic plants in Pipe and Lucerne Lakes, June 2003

Scientific Name	Common Name	Distribution/Density[1]
Potamogeton zosteriformis	Flat-stem pondweed	3
Potamogeton amplifolius	Big-leaf pondweed	1
Potamogeton robbinsii	Fern-leaf pondweed	2
Potamogeton foliosus	Leafy pondweed	3 -4
Hydrilla verticillata	Hydrilla	2
Utricularia sp	Bladderworts	2
Isoetes spp.	Quillworts	2
Scirpus	Bullrushes	2
Juncus spp.	Rushes	2
Typha spp.	Cattails	3
Iris pseudacorus	Yellow-flag iris	3-4
Solanum dulcamara	Bittersweet, nightshade	2
Spirea spp.	Spirea	3-4
Nuphar polysepala	Spatterdock	1
Nymphaea odorata	White water lily	2-3
Polygonum hydropiperoides	Waterpepper	2
Chara	Muskgrass, stonewort	4-5
Nitella	Brittlewort	found in July
Fontinalis antipyretica	Common water moss	found in July

Note 1: Ecology distribution value definitions as follows: 1 = few plants in only one or a few locations, 2 = few plants, but with a wide patchy distrivution, 3 = plants growing in large patches and co-dominant with other plants, 4 = plants in nearly mono-specific patches and dominant, 5 = think growth covering the substrate at the exlusion of other species.

Hydrilla (Hydrilla verticillata)

Hydrilla (*Hydrilla verticillata*) may be considered the most problematic aquatic plant in the United States. This plant is native to Africa, Australia, and parts of Asia but was introduced to Florida in 1960 via the aquarium trade. Hydrilla was discovered in Pipe and Lucerne Lakes in 1994 and was most likely introduced to the lakes as a contaminant on mail order fragrant water lily rhizomes.

Hydrilla is commonly confused with the non-native Brazilian elodea *(Egeria densa)* and native American waterweed *(Elodea canadensis)*. However, there are some distinct differences: the submersed portions of hydrilla are long and sinewy with small pointed leaves, oppositely arranged, in whorls of 3-10. The leaves are sometimes serrated along the edges; the midrib of the leaf is often reddish and has one or more sharp spines. The flowers are tiny, white and grow on long stalks. The distinctive tubers and turions are the reason hydrilla is as successful as it is. Turions are compact "buds" produced along the leafy stems; late in the growing season they break free of the parent plant and drift or settle to the bottom to start new plants. Turions are 1/4 inch long, dark green, and appear spiny. Tubers are small underground white or yellowish potato-like structures that form at the end of roots. Hydrilla produces an abundance of tubers and turions in the fall, and tubers may remain dormant for several years in the sediment. The hydrilla variety found in Pipe and Lucerne Lakes will also make tubers in the spring and will produce non-dormant turions throughout the growing season.

Tubers and turions can withstand ice cover, drying, herbicides, and ingestion and regurgitation by waterfowl.

Aside from the tenacious tubers and turions, the plant has several advantages over other aquatic plants. It will grow with less light and is more efficient at taking up nutrients than other plants. It has extremely effective methods of propagation; besides making seeds (seedlings are actually rarely seen in nature), it can sprout new plants from root fragments or stem fragments containing as few as two whorls of leaves. Recreational users can easily spread these small fragments from waterbody to waterbody by boat motor propellers or trailers. Once hydrilla becomes established, it is readily spread by waterfowl and boating activities.

Hydrilla forms dense mats of vegetation that interfere with recreation and destroy fish and wildlife habitat. The dense mats can increase water temperature by absorbing sunlight, raise the pH, and create stagnant water mosquito breeding areas. When hydrilla becomes dense, swimming becomes dangerous. It also snags fishhooks and inhibits boating by entangling propellers or paddles.

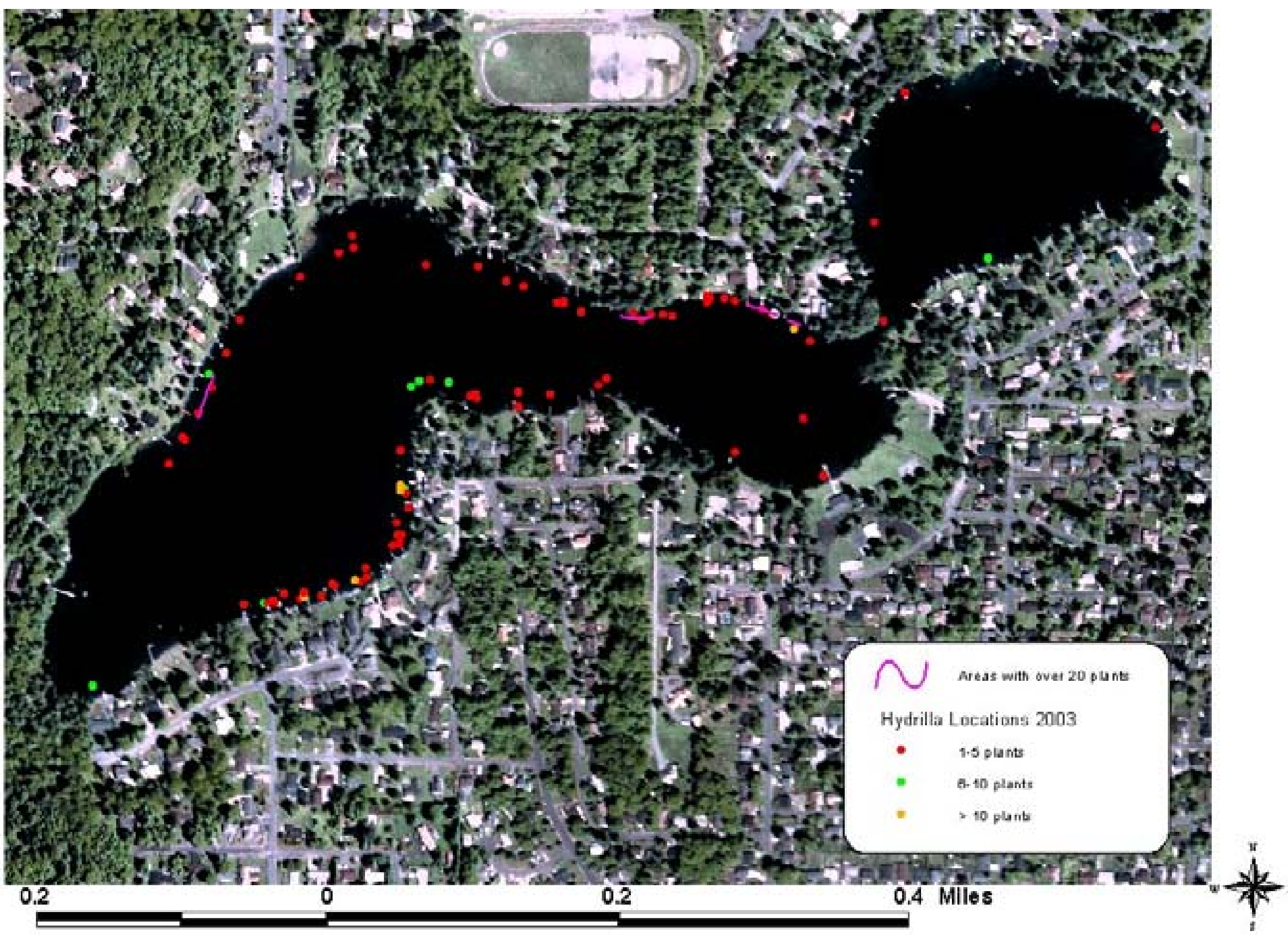

Figure 5: 2003 Hydrilla locations

Fragrant water lily (*Nymphaea odorata*)

This species is native to the eastern half of North America (Washington State Noxious Weed Control Board, 2001b). It was probably introduced into Washington during the Alaska Pacific Yukon Exposition in Seattle in the late 1800's. It has often been introduced to ponds and lakes because of its beautiful, large white or pink (occasionally light yellow), many-petaled flowers that float on the water's surface, surrounded by large, round green leaves. The leaves are attached to flexible underwater stalks rising from thick fleshy rhizomes. Adventitious roots attach the horizontal creeping and branching rhizomes.

This aquatic perennial herb spreads aggressively, rooting in murky or silty sediments in water up to ten feet deep. It prefers quiet waters such as ponds, lake margins and slow streams and will grow in a wide range of pH. Shallow lakes are particularly vulnerable to being totally covered by fragrant water lilies. Water lily spreads by seeds and by rhizome fragments. A planted rhizome will cover about a 15-foot diameter circle in five years (Washington State Noxious Weed Control Board, 2001b).

Fragrant water lily, first introduced most likely by a homeowner, has been known to cover the littoral zone of Pipe and Lucerne Lakes. When left uncontrolled, this species tends to form dense monospecific stands that can persist until senescence in the fall. Mats of these floating leaves prevent wind mixing and extensive areas of low oxygen can develop under the water lily beds in the summer. Water lilies can restrict lakefront access and hinder swimming, boating, and other recreational activities. They may also limit our native water lily (*Nuphar luteum*) with which it overlaps in distribution. Over the years the use of fluridone has greatly decreased the fragrant water lily population, but they still exist in the lake.

Yellow flag iris (*Iris pseudacorus*)

Yellow flag iris is native to mainland Europe, the British Isles, and the Mediterranean region of North Africa (Washington State Noxious Weed Control Board, 2001a). This plant was introduced widely as a garden ornamental and has also been used for erosion control. The earliest collection in Washington is from Lake McMurray in Skagit County in 1948 (Washington State Noxious Weed Control Board, 2001a). The yellow flowers are a distinguishing characteristic, but when not in flower, it may be confused with cattail (*Typha sp*.) or broad-fruited bur-reed (*Sparganium eurycarpum*).

Yellow flag iris is considered an obligate wetland species, with a >99% probability of occurring in wetlands as opposed to upland areas (Reed, 1998). The plants produce large fruit capsules and corky seeds in the late summer. Yellow flag iris spreads by rhizomes and seeds. Rhizome fragments can form new plants. Yellow flag iris can spread by rhizome growth to form dense stands that can exclude even the toughest of our native wetland species, such as cattail.

This noxious weed has already colonized several stretches of shoreline along Pipe and Lucerne Lakes. In addition to threatening to lower plant diversity, this noxious weed can also alter hydrologic dynamics through sediment accretion along the shoreline.

Eurasian watermilfoil (*Myriophyllum spicatum*)

A population of this Class B noxious weed was identified in the 1994 survey. It was eradicated from the lake in a side benefit of the hydrilla control activities.

AQUATIC PLANT CONTROL ALTERNATIVES

This section outlines common methods used to control aquatic weeds. Much of the information in this section is quoted directly from the Ecology's website.

http://www.ecy.wa.gov/programs/wq/plants/management/index.html

Additional information was obtained from the field experience of the King County Noxious Weed Control Program, in particular from Drew Kerr, Aquatic Noxious Weed Specialist and Washington State Department of Agriculture (WSDA) licensed aquatic herbicide applicator.

Control/eradication methods discussed herein include aquatic herbicide, manual methods, bottom screens, diver dredging, and biological control.

Aquatic Herbicides

Description of Method

http://www.ecy.wa.gov/programs/wq/plants/managemetn/aqua028.html

Aquatic herbicides are chemicals specifically formulated for use in water to eradicate or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (EPA) have been reviewed and considered compatible with the aquatic environment when used according to label directions. However, individual states may also impose additional constraints on their use.

Aquatic herbicides are sprayed directly onto floating and emergent aquatic plants or are applied to the water in either a liquid or pellet form. Systemic herbicides are capable of killing the entire plant by translocating from foliage or stems and killing the root. Contact herbicides cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and capable of re-growth (chemical mowing). Non –selective herbicides will generally affect all plants that they come in contact with, both monocots and dicots. Selective herbicides will affect only some plants, usually dicots or broad-leafed plants (broad-leafed plants like Eurasian watermilfoil will be affected by selective herbicides whereas monocots like Brazilian elodea and our native pondweeds may not be affected).

Because of environmental risks from improper application, aquatic herbicide use in Washington State waters is regulated and has certain restrictions. WSDA must license aquatic applicators. In addition, because of a March 2001 court decision (Ninth Circuit Court of Appeals), coverage under a discharge permit called a National Pollutant Discharge Elimination System (NPDES) permit must be obtained before aquatic herbicides can be applied to some waters of the U.S. This ruling, referred to as the Talent Irrigation District decision, has further defined Section 402 of the Clean Water Act. Ecology has developed a general NPDES permit which is available for coverage under the WSDA for the management of noxious weeds growing in an aquatic situation and a separate general permit for nuisance aquatic weeds (native plants) and algae control. For nuisance weeds (native species also referred to as beneficial vegetation) and algae, applicators and the local sponsor of the project must obtain a NPDES permit from Ecology before applying herbicides to Washington water bodies.

Although there are a number of EPA registered aquatic herbicides, the Department of Ecology currently issues permits for five aquatic herbicides (as of 2003 treatment season). Several other herbicides are undergoing review and it is likely that other chemicals may be approved for use in Washington in the future. As an example, Renovate® (Triclopyr) has been approved by the U.S. EPA for aquatic use in November 2002, making it the first aquatic herbicide to receive registration since 1988. Imazapyr also just recently received aquatic registration this year. This herbicide is effective only for emergent or floating leaved vegetation, whereas Renovate is effective on both emergent and submersed plants. Triclopyr and imazapyr have been evaluated by the Department of Ecology's Environmental Impact Statement (EIS) process and both will be approved for use in Washington in spring 2004.

In 1999 the Tri-County Endangered Species Act Response Program was formed between King County, Pierce County, and Snohomish County. The program was to develop a response to the listing of chinook, bull trout, and other fish potentially listed in the Endangered Species Act. Technical groups were formed and one particular group the Tri-County IPM (Integrated Pest Management) was charged with developing recommendations for the reduction of pesticide use by the participating jurisdictions (http://www.govlink.org/hazwaste/interagency/ipm/ipmeo.html). A ranking system of pesticides came out of this effort in the form of Tier Tables. Washington State Toxic Coalition ranked all herbicides based on concern. Products assigned to Tier I are herbicides of greatest concern, while Tier II are of moderate concern, and Tier III are of least concern. Ron Sims, the King County Executive, signed an executive order to follow the IPM approach in 2000.

The chemicals that are currently permitted for use in 2003 are:

Aquatic Herbicides (see Appendix for labels)

- **Glyphosate** - (Trade names for aquatic products with glyphosate as the active ingredient include: Rodeo®, AquaMaster®, and AquaPro®). This systemic broad-spectrum herbicide is used to control floating-leaved plants like water lilies and shoreline plants like purple loosestrife. It is generally applied as a liquid to the leaves. Glyphosate does not work on underwater plants such as Eurasian watermilfoil or hydrilla. Although glyphosate is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed. Plants can take several weeks to die and a repeat application is often necessary to remove plants that were missed during the first application.

- **Fluridone –** (Trade names for fluridone products include: Sonar® and Avast!®). Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil, hydrilla and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not considered effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose. When used to manage Eurasian watermilfoil in Washington, fluridone is applied several times during the spring/summer to maintain a low, but consistent concentration in the water. Although fluridone is considered to be a broad-spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

- **2,4-D** – There are two formulations of 2,4-D approved for aquatic use. The granular formulation contains the low-volatile butoxy-ethyl-ester (BEE) formulation of 2,4-D (Trade names include: AquaKleen® and Navigate®). The liquid formulation contains the dimethylamine salt (DMA)of 2,4-D (Trade name - DMA*4IVM). 2,4-D is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species. Both the granular and liquid formulations can be effective for spot treatment of Eurasian watermilfoil. 2,4-D has been shown to be selective to Eurasian watermilfoil when used at the labeled rate, leaving native aquatic species relatively unaffected. However, 2,4-D is not effective against hydrilla.

- **Endothall - Dipotassium Salt –** (Trade name Aquathol®) Endothall is a fast-acting non-selective contact herbicide, which destroys the vegetative part of the plant but generally does not kill the roots. Endothall may be applied in a granular or liquid form. Typically endothall compounds are used primarily for short-term (one season) control of a variety of aquatic plants, including hydrilla. However, there has been some recent research that indicates that when used in low concentrations, endothall can be used to selectively remove exotic weeds; leaving some native species unaffected. Because it is fast acting, endothall can be used to treat smaller areas effectively. Endothall is not effective in controlling American waterweed (*Elodea canadensis*) or Brazilian elodea (*Egeria densa*).

- **Diquat –** (Trade name Reward®). Diquat is a fast-acting non-selective contact herbicide that destroys the vegetative part of the plant but does not kill the roots. It is applied as a liquid. Typically diquat is used primarily for short-term (one season) control of a variety of submersed aquatic plants. It is very fast-acting and is suitable for spot treatment. However, turbid water or dense algal blooms can interfere with its effectiveness. Diquat was allowed for use in Washington in 2003 and Ecology will be collecting information about its efficacy against Brazilian elodea in 2003. It is effective in controlling hydrilla.

Advantages

- Aquatic herbicide application can be less expensive than other aquatic plant control methods.
- Aquatic herbicides are easily applied around docks and underwater obstructions.
- Other states have experienced success in hydrilla eradication when using Sonar PR®, a slow release fluridone herbicide.

Disadvantages

- Some herbicides have swimming, drinking, fishing, irrigation, and water use restrictions.
- Herbicide use may have unwanted impacts for people who use the water and to the environment.
- Non-targeted plants as well as nuisance plants may be controlled or killed by some herbicides.

- Depending on the herbicide used, it may take several days to weeks or several treatments during a growing season before the herbicide controls or kills treated plants.

- Rapid-acting herbicides like Aquathol may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills.

- To be most effective, generally herbicides must be applied to rapidly growing plants.

- Some expertise in using herbicides is necessary in order to be successful and to avoid unwanted impacts.

- Many people have strong feelings against using chemicals in water.

- Some cities or counties may have policies forbidding or discouraging the use of aquatic herbicides.

Permits

A NPDES permit is needed. The noxious NPDES permits require the development of an Integrated Aquatic Vegetation Management Plan (IAVMP) by the third year of chemical control work. The requirement of monitoring of herbicide levels started in 2003, whether the chemical has been applied directly to the water or along the shoreline where it may have gotten into the adjacent surface water. For noxious weed control, the applicator must apply to the Washington Department of Agriculture (Agriculture) for coverage under their NPDES permit each treatment season. There is no permit or application fee to obtain NPDES coverage under Agriculture's permit for Noxious Weeds.

Costs

Approximate costs for one-acre herbicide treatment (costs will vary from site to site):

- DMA*4IVM: $500-$700

- Navigate and AquaKleen: $500 - $700

- Rodeo or Aquamaster: $250

- Sonar: $900 - $1000

Other Considerations

The focus of the discussion below is on the active ingredient fluridone, since the State, King County Department of Natural Resources and Parks, and other experts in the field have selected this chemical as the best option for the Integrated Treatment Strategy for Pipe and Lucerne Lakes. Neither 2,4-D or the newly registered triclopyr and imazapyr are effective for hydrilla control. The contact herbicides endothall and diquat do not kill the plant's roots and are not considered further.

Washington State Department of Health assembled a fact sheet about the potential effects of fluridone; it is on-line and can be found at http://www.doh.wa.gov/ehp/ts/Fluridone.doc.

Fluridone is moderately persistent in water and sediments following treatment of a pond or lake. Field tests have shown that the average half-life in pond water is 21 days and longer in sediments (90 days in hydrosoil). Residues may persist longer depending on the amount of sunlight and the water temperature. Sunlight and microorganisms primarily degrade Fluridone.

Laboratory animals (mice, rats, dogs) fed fluridone in their diets showed little signs of toxicity even when fed levels which far exceed potential human exposure from use of Sonar. Fluridone is not considered to be a carcinogen or mutagen and is not associated with reproductive or developmental effects in test animals.

There is no EPA standard for maximum allowable concentration (MCL) of fluridone in public water supplies. For the purpose of Sonar product registration, EPA determined that 150 ppb is an acceptable level for potable water following Sonar use. This level provides a 1000-fold safety factor between the no effect level in experimental animals and the estimated human exposure via drinking water.

The Sonar label prohibits application to water within 1/4 mile of functioning potable water intakes unless the treatment rate is 20 ppb or less. Estimated human exposure from daily consumption of water with 20 ppb of fluridone is 10,000-fold less than the no effect level in test animals. People who wish to avoid even minimal residues can do so by filtering their drinking water with a charcoal-based filter. According to the manufacturer, Sonar used at the maximum-labeled rate (150 ppb) may affect domestic plants, especially plants in the *Solanaceae* family (tomato, potato, eggplant, peppers etc.). More dilute concentrations are unlikely to affect domestic plants. Again, a charcoal-based filter will remove fluridone residues from water. Fluridone tends to bind to organic matter and should not leach into groundwater from aquatic sediments. Fluridone shows a limited ability to leach if applied to soil.

There are no swimming or fishing restrictions associated with fluridone treatment. Fluridone does not significantly bioaccumulate or biomagnify in fish. Consumption of fish from treated water does not pose a threat to human health. "Inert" ingredients included in formulations of fluridone are confidential. Washington State Department of Health was permitted to review the list of inerts in Sonar and concluded that these chemicals are not of human concern at applied concentrations.

The Park Commission in Lake George New York looked into using fluridone for Eurasian milfoil treatment in the early 1990's. The following herbicide information is from the Final Supplemental Environmental Impact Statement for Lake George done by the consulting firm ENSR.

Degradation Products and Inert Ingredients

The composition and decay products of Sonar have been discussed in the GEIS, which was part of the registration process for Sonar in New York State. The active ingredient, fluridone, is chemically known as 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4[1H]-pyridinone. The primary inert ingredient in the liquid formulation is water. Additional ingredients in the liquid formulation are surfactants, but these are deleted from Sonar in New York State in accordance with the New York label for Sonar. The primary inert ingredient in the pelletized formulation is clay, with a small amount of binder added to keep the pellet cohesive until placed in the target lake. Sonar does not contain any ingredient on the USEPA List 1 of Inerts of Potential Toxicological Concern or List 2 of Potentially Toxic Inerts/High Priority for Testing.

Fluridone decays mainly by photolysis, with some microbial decomposition also observed. The primary initial metabolite detected in lakes is 1-methyl-3-(4-hydroxyphenyl)-5-[3-(trifluoromethyl)phenyl]-4[1H]-pyridinone, with eventual decay to mainly hydrogen, oxygen and carbon. No toxicological reactions have been reported at doses consistent with the label restrictions in any state, despite extensive studies. A number of other fluridone degradation compounds have been identified in the laboratory, but never under field conditions. Of greatest concern was NMF, a possible teratogen at high concentrations, but this has never been detected outside the lab, even from experimental treatments as high as 446 ppb. NMF was derived from fluridone only under lab conditions involving methanol solutions.

<u>Potential Public Health Impacts</u>

Fluridone has low bioaccumulation potential in animals, and has been processed and excreted within a few days by all organisms tested to date. Detectable accumulations in tissue samples mirror the concentrations in the treated water, and high levels have only been found at very high application rates, over an order of magnitude above those approved for New York State. Impacts on invertebrate populations have not been detected below 300 ppb, with lethality to 50% of the test population not detected at <6300 ppb. For fish, no effects were observed below a concentration of about 500 ppb, with most test populations having a tolerance >1000 ppb. No impairment of bird reproduction was observed at dietary exposure of 1000 ppb, and no acute toxicity was observed for birds exposed to 2000 to 5000 ppb. Toxicity for dogs was not observed up to a dietary exposure level of 500,000 ppb and toxic reactions by rats were not observed up to an exposure of 10,000,000 ppb. Feeding dogs a dose of 150 mg/kg (150,000 ppb) for a year resulted in no toxicological impact and a two-year feeding study produced no carcinogenicity.

The USEPA has established a human tolerance level for fluridone of 0.5 ppm (500 ppb) for consumption of fish and shellfish. As a result of the apparent lack of impact at lower levels, fluridone has been approved for use in potable water supplies at concentrations <20 ppb.

Suitability for Pipe and Lucerne Lakes

Aquatic herbicides can provide an effective method for control and eventual eradication of noxious weeds. The use of a formulation of fluridone has been shown provide excellent initial control of hydrilla while allowing for whole lake treatment. Fluridone is a systemic herbicide, which means it is absorbed and moves within the plant to damage and kill it. Systemic herbicides are generally slower acting than contact herbicides and often less acutely toxic. For the hydrilla eradication project it is more appropriate to use a systemic, longer-lasting herbicide that persists in the water column to ensure control of the hydrilla throughout the growing season. The County has determined through diver observation that the hydrilla tubers sprout at different times of the season depending on water temperature and depth. By maintaining low levels of the fluridone throughout the germination period, all hydrilla plants are being effectively treated. A once-off treatment with a shorter acting herbicide would miss later sprouting plants. Fluridone is the only slow-acting, systemic herbicide effective for hydrilla that is approved for use in Washington State waters.

The sediments in Pipe and Lucerne Lakes are organic but not very flocculent and much of the lakeshore has been armored with either pea gravel or weed barriers. Granular formulations of fluridone, such as Sonar PR®, are effective because the pellets do not sink too deeply into the sediment and a consistent herbicide level is maintained in the water column. This Sonar formulation may not be effective in areas of or in water bodies with flocculent sediment. Maintaining low levels of Sonar is important to the overall goals of the project because hydrilla needs to be exposed to the herbicide as it sprouts throughout the growing season. It has been documented by SePRO, the corporation that sells Sonar, and independent researchers that only very low levels of fluridone are necessary to kill the plants and using the granular formulation of this herbicide should achieve that result.

Using the liquid formulation of fluridone may not be as cost-effective as the granular formulations. Using pellets, the applicator can directly target the areas containing hydrilla. Liquid formulations tend to dilute quickly, requiring multiple whole-lake applications to achieve and maintain target concentrations. There is some evidence from work on Battleground Lake in 2003 that liquid applications do not mix below the thermocline (K. Hamel pers comm). Therefore, hydrilla below that depth cannot be effectively treated using a liquid preparation without using special application techniques. Pellets sink and release the herbicide at the sediment/water interface, so are more easily used in treating infestations that extend below the thermocline.

Conservation Areas

One of the main reasons to eradicate hydrilla is to maintain the health of the native aquatic plant community, as well as to maintain the viability of the lake for human recreational uses. The nature of the control methods to be implemented should minimize impact to native aquatic vegetation. The control of the hydrilla should be conducted by methods designed to preserve (and eventually enhance or conserve) the native plant communities. Herbicides selective to hydrilla should be used for its control. Although fluridone is not a selective herbicide, hydrilla is particularly susceptible to this chemical at low concentrations. Some native plant species are only affected at higher fluridone concentrations. Therefore by using very low levels of fluridone, hydrilla can be effectively killed while allowing for the survival and growth of some native aquatic plants. Also by utilizing the newer granular formulation of Sonar, treatments can be targeted to the areas specifically containing hydrilla. Follow-up control methods such as diver hand-pulling will focus specifically on hydrilla and will leave beneficial plants intact. With these constraints in place, conservation areas should not need to be established to serve vital ecosystem functions until native plants re-establish. The plant community list from 2003 certainly indicates that native plants are surviving and doing reasonably well even though an aquatic herbicide is in the water and at concentrations that are killing hydrilla.

Past community efforts at Pipe and Lucerne Lakes have used aquatic herbicides, so a disagreement from the community with this recommendation is not anticipated. To ensure that all residents who might withdraw water from the lake are aware of water use restrictions, one announcement will be sent to the watershed residents at the beginning of the summer with the anticipated dates of planned treatments. 24 hours prior to each treatment lakeshore will be posted as mandated by the NPDES permit.

Manual Methods

Hand-Pulling

Hand-pulling aquatic plants is similar to pulling weeds out of a garden. It involves removing entire plants (leaves, stems, and roots) from the area of concern and disposing of them in an area away from the shoreline. In water less than three feet deep no specialized equipment is required, although a spade, trowel, or long knife may be needed if the sediment is packed or heavy. In deeper water, hand-pulling is best accomplished by divers with SCUBA equipment and mesh bags for the collection of plant fragments. Some sites may not be suitable for hand-pulling such as areas where deep flocculent sediments may cause a person hand-pulling to sink deeply into the sediment.

Hydrilla raises a special issue when using the hand-pulling technique. Tubers form at the end of the plant rhizomes and are produced by the plant as an overwintering structure. Tubers can lie dormant and viable for several years, eventually producing healthy hydrilla plants. These structures are the deepest part of the plant and when pulled by hand can break off, leaving a viable propagule in the sediment to sprout in following growing seasons. Much concern and care must be taken when pulling the hydrilla. It is often very time-consuming and, even when workers are extremely thorough, can leave several tubers behind in the sediment.

Cutting

Cutting differs from hand-pulling in that plants are cut and the roots and tubers are not removed. It can be performed by standing on a dock or on shore and throwing a cutting tool out into the water. A non-mechanical aquatic weed cutter is commercially available. Two single-sided, razor sharp stainless steel blades forming a “V” shape are connected to a handle, which is tied to a long rope. The cutter can be thrown about 20-30 feet into the water. As the cutter is pulled through the water, it cuts a 48-inch wide swath. Cut plants rise to the surface where they can be removed. Washington State requires that cut plants be removed from the water. The stainless steel blades that form the V are extremely sharp and great care must be taken with this implement. It should be stored in a secure area where children do not have access.

Raking

A sturdy rake makes a useful tool for removing aquatic plants. Attaching a rope to the rake allows removal of a greater area of weeds. Raking literally tears plants from the sediment, breaking some plants off and removing some roots and tubers as well. Specially designed aquatic plant rakes are available. Rakes can be equipped with floats to allow easier plant and fragment collection. The operator should pull towards the shore because a substantial amount of plant material can be collected in a short distance.

Cleanup

All of the manual control methods create plant fragments. It’s important to remove all fragments from the water to prevent them from re-rooting or drifting onshore. Plants and fragments can be composted or added directly to a garden.

Advantages

- Manual methods are easy to use around docks and swimming areas.
- The equipment is inexpensive.
- Hand-pulling allows the flexibility to remove undesirable aquatic plants while leaving desirable plants.
- These methods are environmentally safe.
- Manual methods do not require expensive permits, and can be performed on a small scale with a Hydraulic Project Approval obtained by reading and following the pamphlet Aquatic Plants and Fish (publication #APF-1-98) available from the Washington Department of Fish and Wildlife.

Disadvantages

- As plants re-grow or fragments re-colonize the cleared areas, the treatment may need to be repeated several times each summer.
- Because these methods are labor intensive, they may not be practical for large areas or for thick weed beds.
- Even with the best containment efforts, it is difficult to collect all plant fragments, leading to re-colonization.
- Some plants, like water lilies, which have massive rhizomes, are difficult to remove by hand-pulling.
- Pulling weeds and raking stirs up the sediment and makes it difficult to see remaining in plants. Sediment re-suspension can also increase nutrient levels in lake water.
- Hand-pulling and raking impacts bottom-dwelling animals.

Permits

Permits are required for many types of manual projects in lakes and streams. The Washington State Department of Fish and Wildlife requires a Hydraulic Project Approval permit for all activities taking place in the water including hand-pulling, raking, and cutting of aquatic plants.

Costs

- Hand-pulling costs up to $130 for the “average” waterfront lot for a hired commercial puller.
- A commercial grade weed cutter costs about $130 with accessories. A commercial rake costs about $95 to $125. A homemade weed rake costs about $85 (asphalt rake is about $75 and the rope costs 35-75 cents per foot).

Other Considerations

The community may need to invest money into buying the equipment and operation. Manual methods must include regular scheduled surveys to determine the extent of the remaining weeds and /or the appearance of new plants after eradication has been attained. This is a large time investment by lakeside residents.

Suitability for Pipe and Lucerne Lakes

Based on the several ways hydrilla propagates, most manual methods are not appropriate for hydrilla eradication. Several of the methods create plant fragments, which can spread the hydrilla throughout the lake. Tubers also can lay dormant in the sediment for several years and these methods do not take that into account. The current infestations are too large and too deep to use manual techniques as the sole source of control. Costs might also be considerably higher than an integrated approach including herbicide applications.

Based on other hydrilla eradication projects, hand-pulling is a key element of the eradication strategy as the project progresses. Divers and snorkelers will be pulling plants as they are found throughout the growing season. When used in an integrated approach, diver hand-pulling is an effective spot control technique.

Diver Dredging

Diver dredging (suction dredging) is a method whereby SCUBA divers use hoses attached to small dredges (often dredges used by miners for mining gold from streams) to suck plant materiel from the sediment. The purpose of diver dredging is to remove all parts of the plant including the roots. A good operator can accurately remove target plans, like hydrilla, while leaving native species untouched. The suction hose pumps the plant material and the sediments to the surface where they are deposited into a screened basket. The water and sediment are returned back to the water column (if the permit allows this), and the plant material is retained. The turbid water is generally discharged to an area curtained off from the rest of the lake by a silt curtain. The plants are disposed of on shore. Removal rates vary from approximately 0.25 acres per day to one acre per day depending on plant density, sediment type, size of team, and diver efficiency. Diver dredging is more effective in areas where softer sediment allows easy removal or the entire plants, although water turbidity is increased with softer sediments. Harder sediment may require the use of a knife or tool to help loosen sediment form around the roots. In very hard sediments, hydrilla can break and leave roots and tubers behind, defeating the purpose of diver dredging.

Advantages

- Diver dredging can be a very selective technique for removing pioneer colonies of hydrilla.
- Divers can remove plants around docks and in other difficult to reach areas.
- Diver dredging can be used in situations where herbicide use is not an option for aquatic plant management.

Disadvantages

- Diver dredging is very expensive, between $1,500 - $2,000 a day.

- Dredging stirs up large amount of sediment. This may lead to the release of nutrients or long-buried toxic materials into the water column.

- Only the tops of plants growing in rocky or hard sediments may be removed, leaving a viable root crown or tuber behind to initiate growth.

- In some states, acquisition of permits can take years.

Permits

Permits are required for many types of projects in lakes and streams. Diver dredging requires Hydraulic Approval from the Department of Fish and Wildlife. Local cities and counties must be checked for any local requirements before proceeding with a diver-dredging project. Also diver dredging may require a Section 404 permit from the US Army Corps of Engineers.

Costs

Depending on the density of the pants, specific equipment used, number of divers and disposal requirements, and costs can range from a minimum of $1,500 to $2,000 per day.

Other Considerations

It might be good spot control method in subsequent years (coordinated with diver survey).

Suitability for Pipe and Lucerne Lakes

Diver dredging removes the plant in its entirety. It removes the biomass above the sediment as well as the tubers in the sediment.

This option is best used for pioneering infestations and in soft sediments. The hydrilla in Pipe and Lucerne Lakes are established infestations, although populations have been much reduced through management methods. Although much of the sediment is soft, many tubers have been found in the harder sediment layers of the lake bottom. It is likely that diver dredging in these harder sediment layers would cause the hydrilla plants to break off, leaving the tubers behind to resprout. This option is also a very expensive method, much more so than using fluridone treatment and diver hand removal. Diver dredging disturbs sediments and can affect nutrient concentrations and algal production in the lake. Diver dredging would be an option in the soft sediments in Pipe and Lucerne. However, in the late 1970's when the drawdowns occurred some residents lined their shoreline with bottom barriers, which could be pose a problem to diver dredging. There is also no formal map that shows the properties where these barriers have been placed.

Bottom Screens

A bottom screen or benthic barrier covers the sediment like a blanket, compressing aquatic plants while reducing or blocking light. Materials such as burlap, plastics, perforated black Mylar, and woven synthetics can all be used as bottom screens. Some people report success using pond liner materials. There is also a commercial bottom screen fabric called Texel, a heavy, felt-like polyester material, which is specifically designed for aquatic plant control.

An ideal bottom screen should be durable, heavier than water, reduce or block light, prevent plants from growing into and under the fabric, be easy to install and maintain, and should readily allow gases produced by rotting weeds to escape without "ballooning" the fabric upwards.

Even the most porous materials, such as window screen, will billow due to gas buildup. Therefore, it is very important to anchor the bottom barrier securely to the bottom. Unsecured screen can create navigation hazards and are dangerous to swimmers. Anchors must be effective in keeping the material down and must be regularly checked. Natural materials such as rocks or sandbags are preferred as anchors.

The duration of weed control depends on the rate that weeds can grow through or on top of the bottom screen, the rate that new sediment is deposited on the barrier, and the durability and longevity of the material. For example, burlap may rot within two years, plants can grow through window screening material, or may grow on top of felt-like Texel fabric. Regular maintenance is essential and can extend the life of most bottom barriers.

Bottom screens will control most aquatic plants; however, freely-floating species such as the bladderworts or coontail will not be controlled by bottom screens. Plants like hydrilla may send out stolons that could potentially canopy over the area that has been screened giving inadequate control.

In addition to controlling nuisance weeds around docks and in swimming beaches, bottom screening has become an important tool to help eradicate and contain early infestations of noxious weeds such as Eurasian watermilfoil and Brazilian elodea. Pioneering colonies that are too extensive to be hand pulled can sometimes be covered with bottom screening material. For these projects, burlap is appropriate with rocks or burlap sandbags for anchors. By the time the material decomposes, the milfoil patches will be dead as long as all plants were completely covered.

Bottom screens can be installed by the homeowner or by a commercial plant control specialist. Installation is easier in winter or early spring when plants have died back. In summer, cutting or hand-pulling the plants first will facilitate bottom screen installation. Research has shown that much more gas is produced under bottom screens that are installed over the top of aquatic plants. The less plant material that is present before installing the screen, the more successful the screen will be in staying in place. Bottom screen may also be attached to frames rather than placed directly onto the sediment. The frames may then be moved for control of a larger area.

Advantages

- Installation of a bottom screen creates and immediate open area of water.
- Bottom screens are easily installed around docks and in swimming areas.

- Properly installed bottom screens can control up to 100 percent of aquatic plants.

- Screen materials are readily available and can be installed by homeowners or by divers.

Disadvantages

- Because bottom screens reduce habitat by covering the sediment, they are suitable only for localized control.

- For safety and performance reasons, bottom screens must be regularly inspected and maintained.

- Harvesters, rotovators, fishing gear, propeller backwash, or boat anchors may damage or dislodge bottom screens.

- Improperly anchored bottom screens may create safety hazards for boaters and swimmers.

- Poorly maintained anchors used to pin bottom screens to the sediment may injure swimmers.

- Some bottom screens are difficult to anchor on deep muck sediments.

- Bottom screens interfere with fish spawning and bottom-dwelling animals.

- Without regular maintenance aquatic plants may quickly colonize the bottom screen.

Permits

Bottom screening in Washington State requires Hydraulic Project Approval. Local jurisdictions may require shoreline permits.

Costs

Barrier materials cost approximately $0.22 to $1.25 per square foot. The cost of some commercial barriers includes an installation fee.

Commercial installation costs vary depending on sediment characteristics and type of bottom screen selected. It costs up to about $750 to have 1,000 square feet of bottom screen installed. Maintenance costs for a waterfront lot are about $120 each year.

Other Considerations

None

Suitability for Pipe and Lucerne Lakes

Bottom barriers have been used in Pipe and Lucerne to control other aquatic plants before the hydrilla infestation. They were originally placed to control water lily growth in the 1970’s. These barriers may have worked in the short term for control but it has been found that hydrilla plants colonize on sediments that settle on the barriers, and show growth through rips and tears in the fabric. Without constant upkeep and maintenance the long-term benefits of bottom barriers are minimal. Currently, infested areas are too large to use a bottom barrier without becoming cost prohibitive. The main disadvantage of bottom barriers for hydrilla eradication is that the tubers may remain viable for years. If the barrier becomes dislodged, decomposes, or is ripped, hydrilla tubers may then germinate.

Biological Control

General Overview

Many problematic aquatic plants in the western United States are non-indigenous species. Plants like hydrilla, Eurasian watermilfoil, Brazilian elodea, and purple loosestrife have been introduced to North America from other continents. Here they grow extremely aggressively, forming monocultures that exclude native aquatic plants and degrade fish and wildlife habitat. Yet, often these same species are not aggressive or invasive in their native range. This may be in part because their populations are kept under control by insects, diseases, or other factors not found in areas new to them.

The biological control of aquatic plants focuses on the selection and introduction of other organisms that have an impact on the growth or reproduction of target plants, usually from their native ranges. Theoretically, by stocking an infested water body or wetland with these organisms, the target plant can be controlled and native plants can recover.

Classical biological control uses control agents that are host specific. These organisms attack only the species targeted for control. Generally these biocontrol agents are found in the native range of the invasive aquatic plants and, like the targeted plant, these biocontrol agents are also non-indigenous species. With classic biological control an exotic species is introduced to control another exotic species. However, extensive research must be conducted before release to ensure that biological control agents are host specific and will not harm the environment in other ways. The authors of *Biological Control of Weeds – A World Catalogue of Agents and Their Target Weeds* assert that after 100 years of using biocontrol agents, there are only eight examples, world-wide, of damage to non-target plants, "one of which has caused serious economic or environmental damage…"

Search for a classical biological control agent typically starts in the region of the world that is home to the invasive aquatic plant. Researchers collect and rear insects and/or pathogens that appear to have an impact on the growth or reproduction of the target species. Those insects/ pathogens that appear to be generalists (feeding or impacting other aquatic plant species) are rejected as biological control agents. Insects that impact the target species (or very closely related species) exclusively are considered for release.

Once collected, these insects are reared and tested for host specificity and other parameters. Only extensively researched, host-specific organisms are cleared by the United States for release. It generally takes a number of years of study and specific testing before a biological control agent is approved.

Even with an approved host-specific bio-control agent, control can be difficult to achieve. Some biological control organisms are very successful in controlling exotic species and others are of little value. A number of factors come into play. It is sometimes difficult to establish reproducing populations of a biocontrol agent. The ease of collection of the biocontrol organism and its placement on the target species can also have a role in the effectiveness. Climate or other factors may prevent its establishment, with some species not proving capable of over-wintering in their new setting. Sometimes the biocontrol insects become prey for native predator species, and sometimes the impact of the insect on the target plants just is not enough to control the growth and reproduction of the species.

People who work in this field say that the more biological control species that you can put to work on a problem plant, the better success you will have in controlling the targeted species. There are some good examples where numerous biological control agents have had little effect on a targeted species, and other examples where one bio-control agent was responsible for the complete control of a problem species.

However, even when biological control works, a classic biological control agent generally does not totally eliminate all target plants. A predator-prey cycle establishes where increasing predator populations will reduce the targeted species. In response to decreased food supply (the target plant is the sole food source for the predator), the predator species will decline. The target plant species rebounds due to the decline of the predator species. The cycle continues with the predator populations building in response to an increased food supply.

Although a successful biological control agent rarely eradicates a problem species, it can reduce populations substantially, allowing native species to return. Used in an integrated approach with other control techniques, biological agents can stress target plants making them more susceptible to other control methods.

A number of exotic aquatic species have approved classical biological control agents available for release in the U.S. These species include hydrilla, water hyacinth, alligator weed, and purple loosestrife.

In 1992 three beetles were released in Washington for purple loosestrife control. Their damaging impact on purple loosestrife populations was evident in the Winchester Wasteway areas of Grant County in 1996. Since 1998, the Washington State Noxious Weed Control Board organized insect collection for state, local, and federal staff. Thousands of insects were collected and distributed to purple loosestrife sites throughout the state and even the United States. The King County Noxious Weed Control Program has placed *Galerucella* sp. from the Winchester Wasteway on a number of purple loosestrife sites. These sties were chosen because of the high density of the target plant and the fact that other control methods were impractical. The sites were in complex wetland habitats with a high presence of native vegetation that would be damaged by chemical applications or repeated foot traffic through the wetland to implement manual control methods.

There are some insects for hydrilla control. The following information is from this website http://www.invasive.org/eastern/biocontrol/7Hydrilla.html.

Four hydrilla insects have been released in the United States: The tuber attacking weevil *Bagous affinis* Hustache (Coleoptera: Curculionidae) and the leaf mining fly *Hydrellia pakistanae* Deonier (Diptera: Ephydridae) were both released in 1987; another leaf-mining fly *H. balciunasi* Bock (Diptera:

Ephydridae) was released in 1989; and the stem-mining weevil *B. hydrillae* O'Brien (Coleoptera: Curculionidae) was released in 1991 (Buckingham, 1994).

The leaf-mining flies have been the most extensively released species. *Hydrellia pakistanae* has been released at more than 50 sites in Alabama, California, Florida, Georgia, Louisiana, and Texas (Center *et al*., 1997). About 1.2 million individuals were obtained, mainly from greenhouse colonies maintained at the U.S. Army Engineer Research and Development Center in Vicksburg, Mississippi and various USDA, ARS facilities, along with an additional two million insects from a Tennessee Valley Authority pond-based rearing facility (Grodowitz and Snoddy, 1995). These releases ended in 1995. Recently (September 2000), releases resumed using *Hydrellia*-containing hydrilla obtained from ponds at the Lewisville Aquatic Ecosystem Research Facility, Lewisville, Texas with more than 300,000 immatures being released in Lake Raven in Huntsville State Park, Texas.

Although four insects have been released, neither of the weevils appears to have established, and *H. balciunasi* has only been recovered from a few sites in east Texas (Bennett and Buckingham, 1999; Grodowitz *et al*., 2000a). However, *H. pakistanae* established and dispersed readily and is now found throughout Florida; north to Muscle Shoals, Alabama; west to Austin, Texas; and south to the lower Rio Grande Valley (Center *et al*., 1997; Grodowitz *et al*., 1997; Grodowitz *et al*., 2000a). Populations of both species, but especially *H. pakistanae*, have expanded in distribution considerably since they were first released.

Another type of biological control uses general agents such as grass carp (see below) to manage problem plants. Unlike classical bio-control agents, these fish are not host specific and will not target specific species. Although grass carp do have food preferences, under some circumstances, they can eliminate all submersed vegetation in a waterbody. Like classic biological control agents, grass carp are exotic species and originate from Asia. In Washington, all grass carp must be certified sterile before they can be imported into the state. There are many waterbodies in Washington (mostly smaller sites) where grass carp are being used to control the growth of aquatic plants.

During the past decade a third type of control agent has emerged. In this case, a native insect that feeds and reproduces on northern milfoil (*Myriophyllum sibericum*), which is native to North America, was found to also utilize the non-native Eurasian watermilfoil (*Myriophyllum spicatum*). Vermont government scientists first noticed that Eurasian watermilfoil had declined in some lakes and brought this to the attention of researchers. It was discovered that a native watermilfoil weevil (*Euhrychiopsis lecontei*) feeding on Eurasian watermilfoil caused the stems to collapse. Because native milfoil has thicker stems than Eurasian watermilfoil, the mining activity of the larvae does not cause it the same kind of damage. A number of declines of Eurasian watermilfoil have been documented around the United States and researchers believe that weevils may be implicated in many of these declines.

Several researchers around the United States (Vermont, Minnesota, Wisconsin, Ohio, & Washington) have been working to determine the suitability of this insect as a bio-control agent. The University of Washington is conducting research into the suitability of the milfoil weevil for the biological control of milfoil in Washington lakes and rivers. Surveys have shown that in Washington the weevil is found more often in eastern Washington lakes and it seems to prefer more alkaline waters. However, it is also present in cooler, wetter western Washington. The most likely candidates for use as biological controls are discussed in the following section.

Grass Carp

http://www.ecy.wa.gov/programs/wq/plants/management/aqua024.html

The grass carp (*Cteno pharynogodon*), also known as the white amur, is a vegetarian fish native to the Amur River in Asia. Because this fish feeds on aquatic plants, it can be used as a biological tool to control nuisance aquatic plant growth. In some situations, sterile (triploid) grass carp may be permitted for introduction into Washington waters.

Permits are most readily obtained if the lake or pond is privately owned, has no inlet or outlet, and is fairly small. The objective of using grass carp to control aquatic plant growth is to end up with a lake that has about 20 to 40 percent plant cover, not a lake devoid of plants. In practice, grass carp often fail to control specific plants, or in cases of overstocking, all the submersed plants are eliminated from the waterbody.

The Washington Department of Fish and Wildlife determines the appropriate stocking rate for each waterbody when they issue the grass carp-stocking permit. Stocking rates for Washington lakes generally range from nine to 25 fish in the size range of eight to eleven-inches per vegetated acre of lake bottom. This number will depend on the amount and type of plants in the lake as well as spring and summer water temperatures. To prevent stocked grass carp from migrating out of the lake and into streams and rivers, all inlets and outlets to the pond or lake must be screened. For this reason, residents on waterbodies that support a salmon or steelhead run are rarely allowed to stock grass carp into these systems.

Once grass carp are stocked in a lake, it may take from two to five years for them to control invasive or nuisance plants. Survival rates of the fish will vary depending on factors like presence of otters, birds or prey, or fish disease. A lake will probably need restocking about every ten years.

Success with grass carp in Washington has been varied. Sometimes the same stocking rate results in no control, control, or even complete elimination of all underwater plants. Bonar *et. al*. found that only 19 percent of 98 Washington lakes stocked with grass carp at a median level of 24 fish per vegetated acre had aquatic plants controlled to an intermediate level. In 39 percent of the lakes, all submersed plants species were eradicated. It has become the consensus among researchers and aquatic plant managers around the county that grass carp are an eradication option, not a control option. They should be stocked only in waterbodies where complete elimination of all submersed plant species can be tolerated.

Grass carp exhibit definite food preferences, and they will consume some aquatic plant species more readily than others. Pauley and Bonar performed experiments to evaluate the importance of 20 Pacific Northwest aquatic plant species as food items for grass carp. Grass carp did not remove plants in a preferred species-by-species sequence in multi-species plant communities. Instead they grazed simultaneously on palatable plants of similar preference before gradually switching to less preferred groups of plants. The relative preference of many plants was dependent upon what other plants were associated with them. The relative preference rank for the 20 aquatic plants tested was as follows: *Potamogeton crispus* (curly leaf pondweed) = *P. pectinatus* (sago pondweed) > *P. zosteriformes* (flat-stemmed pondweed) > *Chara* sp. (muskgrasses) = *Elodea canadensis* (American waterweed) = *Potamogeton* spp. (thin-leaved pondweeds) > *Egeria densa* (Brazilian elodea) (large fish only) > *Myriophyllum spicatum* (Eurasian watermilfoil) > *Ceratophyllum demersum* (coontail)> *Utricularia* *vulgaris* (bladderwort) > *Polygonum amphibium* (water smartweed) > *P. natans* (floating leaved pondweed) > *P. amplifolius* (big leaf pondweed) > *Brasenia schreberi* (watershield) = *Juncus* sp. (rush) > *Egeria densa* (Brazilian elodea) (fingerling fish only) > *Nymphaea* sp. (Fragrant water lily) > *Typha* sp. (cattail) > *Nuphar* sp. (spatterdock).

Generally in Washington, grass carp do not consume emergent wetland vegetation or water lilies even when the waterbody is heavily stocked or over stocked. A heavy stocking rate of triploid grass carp in Chamber Lake, Thurston County resulted in the loss of most submersed species, whereas the fragrant water lilies, bog bean, and spatterdock remained at pre-stocking levels. A stocking of 83,000 triploid grass carp in Silver Lake, Washington resulted in the total eradication of all submersed species, including Eurasian watermilfoil, Brazilian elodea, and swollen bladderwort. However, the extensive wetlands surrounding Silver Lake have generally remained intact. In southern states, grass carp have been shown to consume some emergent vegetation (Washington State Department of Ecology, 2002).

Grass carp stocked into Washington lakes must be certified disease free and sterile. Sterile fish, called triploids because they have an extra set of chromosome, are created when the fish eggs are subjected to temperature or pressure shock. Fish are verified sterile by collecting and testing a blood sample. Triploid fish have slightly larger blood cells and can be differentiated from diploid (fertile) fish by this characteristic. Grass carp imported into Washington must be tested to ensure that they are sterile.

Because Washington does not allow fertile grass carp within the state, they are imported into Washington from out of state locations. Most grass carp farms are located in the southern United States where warmer weather allows for fast fish growth rates. Large shipments are transported in special trucks and small shipments arrive via air.

Here are some further facts about grass carp:

- Are only distantly related to the undesirable European carp, and share few of its habits.
- Generally live for at least ten years and possibly much longer in Washington State waters.
- Will grow rapidly and reach at least ten pounds. They have been known to reach 40 pounds in the southern United States.
- Will not eat fish eggs, young fish or invertebrates, although baby grass carp are omnivorous.
- Feed from the top of the plant down so that mud is not stirred up. However, in ponds and lakes where grass carp have eliminated all submersed vegetation the water becomes turbid. Hungry fish will eat organic material out of the sediments.
- Have definite taste preferences. Plants like Eurasian milfoil and coontail are not preferred. American waterweed and thin-leaved pondweeds are preferred. Water lilies are rarely consumed in Washington waters.
- Are dormant during the winter. Intensive feeding starts when water temperatures reach 68 F
- Prefer flowing water to still waters (original habitat is fluvial).

- Are difficult to recapture once released.

- They may not feed in swimming areas, docks, boating areas, or other sites where there is heavy human activity.

Advantages

- Grass carp are inexpensive compared to some other control methods and offer long-term control, but fish may need to be restocked at intervals.

- Grass carp offer a biological alternative to aquatic plant control.

Disadvantages

- Depending on plant densities and types, it may take several years to achieve plant control using grass carp and in many cases control may not occur.

- If the waterbody is overstocked, all submersed aquatic plants may be eliminated. Removing excess fish is difficult and expensive.

- The type of plants grass carp prefer may also be those most important for habitat and for waterfowl food.

- If not enough fish are stocked, less-favored plants, such as Eurasian watermilfoil, may take over the lake.

- Stocking grass carp may lead to algae blooms.

- All inlets and outlets to the lake or pond must be screened to prevent grass carp from escaping into streams, rivers, or other lakes.

Permits

Stocking grass carp requires a fish-stocking permit from the Washington Department of Fish and Wildlife. Also, if inlets or outlets need to be screened to prevent carp escapement, a Hydraulic Project Approval application must be completed for the screening project.

Costs

In quantities of 10,000 or more, eight to 12 inch sterile grass carp can be purchased for about $5.00 each for truck delivery. The cost of small air freighted orders will vary and is estimated at $8 to $10 per fish.

Other Considerations

- Would not achieve immediate results – takes time and are not guaranteed to work.

- Community may have concerns with introduced species.
- Potential damage to the native plant community of the lake, which could result in the establishment of other aggressive plant species as pioneers.
- Concerns for fishermen about grass carp.
- Initial investment very expensive.
- The introduction of grass carp has generally been discouraged by state agencies.

Suitability for Pipe and Lucerne Lakes

Biological controls are not a preferred method for hydrilla eradication. The biocontrol insects are generally adapted to warmer climates found in the southern US and most likely would not establish or provide much control in Washington. They also would not eradicate the infestation, but would only provide control. This is not the goal of this IAVMP. Grass carp might eradicate hydrilla if enough fish were stocked since hydrilla is a highly preferred species. However, grass carp can live for 20 years and there is no effective way of removing them once eradication is achieved. Grass carp may also eliminate many native beneficial species from Pipe and Lucerne Lakes. Therefore, at this time, biocontrols are not being considered for use in these lakes.

Rotovation, Harvesting, and Cutting

Rotovation

Rotovators use underwater rototiller-like blades to uproot hydrilla plants. The rotating blades churn seven to nine inches deep into the lake or river bottom to dislodge plant root crowns that are generally buoyant. The plants and roots may then be removed from the water using a weed rake attachment to the rototiller head or by harvester or manual collection.

Harvesting

Mechanical harvesters are large machines, which both cut and collect aquatic plants. Cut plants are removed from the water by a conveyor belt system and stored on the harvester until disposal. A barge may be stationed near the harvesting site for temporary plant storage or the harvester carries the cut weeds to shore. The shore station equipment is usually a shore conveyor that connects to the harvester and lifts the cut plants into a dump truck. Harvested weeds are disposed of in landfills, used as compost, or in reclaiming spent gravel pits or similar sites.

Cutting

Mechanical weed cutters cut aquatic plants several feet below the water's surface. Unlike harvesting, cut plants are not collected while the machinery operates.

Suitability for Pipe and Lucerne Lakes

None of these options are suitable for the hydrilla infestation at Pipe and Lucerne Lakes. They are not eradication tools, but rather are used to manage and control heavy, widespread infestations of aquatic weeds. These processes create plant fragments, and therefore would likely spread hydrilla rather than suppress its growth. These methods should not be used for hydrilla. According to Ecology, "there is little or no reduction in plant density with mechanical harvesting." Since the aim of the project is to eradicate hydrilla from the system, these are not compatible control strategies. Harvesting and cutting do not remove root systems. Rotovation would cause damage to the lake sediments and associated animals in a system that does not already receive dredging for navigability.

Drawdown

Lowering the water level of a lake or reservoir can have a dramatic impact on some aquatic weed problems. Water level drawdown can be used where there is a water control structure that allows the managers of lakes or reservoirs to drop the water level in the waterbody for extended periods of time. Water level drawdown often occurs regularly in reservoirs for power generation, flood control, or irrigation; a side benefit being the control of some aquatic plant species. However, regular drawdowns can also make it difficult to establish native aquatic plants for fish, wildlife, and waterfowl habitat in some reservoirs.

Suitability for Pipe and Lucerne Lakes

Drawdown is not an appropriate control measure because neither Pipe nor Lucerne Lake have an outlet structure that allows water levels to be controlled. In addition tuber-forming species such as hydrilla are often not affected by drawdown because tubers can remain viable and will germinate when the water levels returns. Finally, drawdown would not result in the eradication of hydrilla, which is the goal of this IAVMP.

Nutrient Reduction

Nutrient Reduction Alternative

At lakes in watersheds with identifiable sources of excess nutrients, a program to reduce nutrients entering the lake could possibly be an effective method of controlling aquatic vegetation. Sources of excessive nutrients might include failing septic tanks, other accidental or planned wastewater effluent, or runoff from agricultural lands. If nutrient reduction were enacted as the primary method of weed control, extensive research would be necessary to determine the current nutrient budget for the lake and surrounding watershed, whether nutrient reduction would result in hydrilla reduction, and to identify and mitigate the natural and human-mediated nutrient sources.

Suitability for Pipe and Lucerne

Nutrient reduction is not an appropriate control measure for the following reasons:

- It is not an eradication method.

- There is no evidence that there is significant point-source nutrient loading at Pipe and Lucerne Lakes.

- There is no evidence that reducing nutrient loads to the water column would impact hydrilla growth.

However, all lake groups should strive to reduce nutrient loading to their lake by practicing and implementing Best Management Practices.

No Action Alternative

This is not an option for Pipe and Lucerne Lake as hydrilla is a Class A noxious weed, listed on the Washington State noxious weed list. Hydrilla is mandated by WAC 16-750 and RCW 17.10 to be controlled and eradicated.

INTEGRATED TREATMENT PLAN

Pipe and Lucerne Lakes are infested with hydrilla. It is the only infestation in the entire Pacific Northwest and needs to be completely eradicated to halt the degradation in the lakes and perhaps most-importantly to prevent it from spreading into other Northwestern waterbodies. Although hydrilla is very difficult to eradicate, eradication is a reasonable and tangible goal, and we can be successful given the proper plan and time frame. California has successfully eradicated numerous hydrilla infestations in many water bodies throughout the state. They have provided a model for Washington to emulate. However, it is critical to remain flexible in treatment options as if conditions of the lake or situations change a new eradication method will need to be adopted and this plan will allow for that.

Hydrilla (*Hydrilla verticillata*)

Control of hydrilla will be accomplished using a granular aquatic formulation of fluridone (Sonar PR®). Herbicide applications will begin at the start of the growing season, about May, and treatment will continue at set intervals throughout the season until September. According to the label no more than 150 ppb of fluridone per season can be used in any one area of the lake. Approximately 15 acres (based on the 2003 surveys) will be treated in 2004. It is anticipated that the areas treated each year will be progressively less extensive as the tuber bank becomes depleted and no new tubers are formed. The contractors hired to survey infestation locations will use a GPS to mark all areas of hydrilla found throughout the growing season. This information will be used to define the areas of herbicide treatment.

For each infestation found, a three-acre buffer is drawn around it to ensure that potential tubers dormant in surrounding sediments will be in contact with the herbicide. The herbicide applicator will generate an ArcView map that will outline the areas for treatment. Using a 17-foot aluminum boat and a pellet herbicide spreader, the fluridone will be applied to the areas of hydrilla. In case studies where hydrilla eradication has been achieved and where the sediments were not too flocculent, slow release fluridone has become the preferred alternative. The 2003 growing season was the first year of using Sonar PR, a granular slow release formulation of fluridone. The herbicide was applied four times in 2003 in Pipe Lake (twice in June, once in both July and August), while there were only 3 applications in Lucerne Lake (twice in June and once in July) due to persistent high levels of fluridone in the water column after treatment. No more than 150 ppb of fluridone will be applied to any one area of hydrilla infestation in a given year. Diver hand-pulling (or diver dredging) will attempt to remove hydrilla as it is found during surveys.

The National Pollutant Discharge Elimination System permit coverage from the Washington State Department of Agriculture (WSDA) requires notification and posting of the waterbody, and these specific protocols will be followed. The NPDES permit also requires monitoring of the herbicide levels in the lake after treatment. Independent samples will be collected prior to the first treatment and then every 14 days thereafter. Several samples will be taken in the treatment areas, middle of the lakes, and in any public use area. Samples will be taken at one meter deep, and in each lake one deeper sample (approximately seven meters) will be taken to insure the fluridone is mixing below the lakes thermocline. These samples will be shipped to the SePRO labs, the fluridone distributor. Samples will be taken every 14 days after the first application throughout the treatment season.

PLAN ELEMENTS, COSTS, AND FUNDING

Table 5 outlines the tasks and estimated costs of implementation on an annual basis. Implementation of the Pipe and Lucerne Lakes IAVMP will span at least five years (2004 through 2008), at a total projected cost of approximately $350,000. The majority of the costs accrue in the first two years, which are projected to involve the most aggressive treatments.

Table 5 shows the total spent for each task. In 2003, a total of $106,497 was spent by King County, of which $91,483 was considered eligible for grant reimbursal. The difference between the two amounts reflects the indirect costs accrued by King County in managing the project and the cap on indirect costs allowed by the grant contract. The cities of Maple Valley and Covington contributed the necessary matching funds to the grant for a total of $7,867. The table also includes the estimated costs for the 2004 treatment year, based on similar work to be performed, with the same financial agreements in place between jurisdictions.

Sources

Hydrilla eradication is the state's highest priority for plant control. It is anticipated that King County will continue to receive grant funding from Ecology until the hydrilla infestation has been confirmed eradicated. There are several sources of funding available for project implementation:

Grants

The Washington State Department of Ecology has an Aquatic Weeds Management Fund (AWMF). This IAVMP was developed to be consistent with all AWMF guidelines and requirements.

Table 5: Hydrilla Eradication Project Budget

Hydrilla Eradication Project Budget		
Task	**Costs 2003**	**Est. 2004 costs**
Project Management	12,311.96	13,225.00
Treatment	43,888.53	47,351.00
Snorkeling and Dive Assessment	34,282.70	37,892.00
Total	91,483.19	98,468.00
Washington State Department of Ecology	83,615.63	TBD
Cities Match	7,867.55	TBD

Dedicated non-grant funds from municipalities

The cities of Maple Valley and Covington have dedicated funds to match the Ecology Grant. Maple Valley was dedicated $5336.55, or 5.1% of the grant, and Covington has dedicated $3243.79 or 3.1% of the grant, in the 2002 funding cycle. Future matches are anticipated to be approximately the same.

Community Based Funding

There are no matching funds coming from the community. This was a state initiated control project, and the state and municipalities agreed to take financial responsibility of the project.

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APPENDIX A

Appendix A contains historical hydrilla location maps compiled from the Resource Mangement Inc. reports beginning in 1995. The maps are arranged chronologically, beginning with what is believed to be the original plant map from 1995. The appendix also includes the most recent hydrilla location map from 2003.

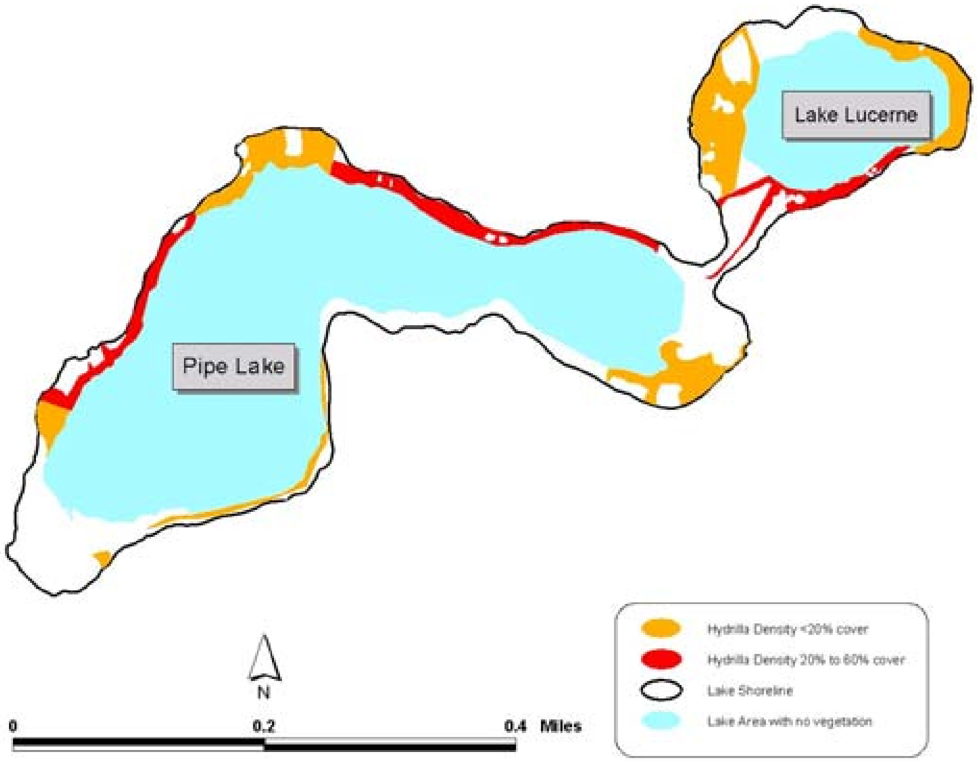

Figure 1: 1995 hydrilla locations

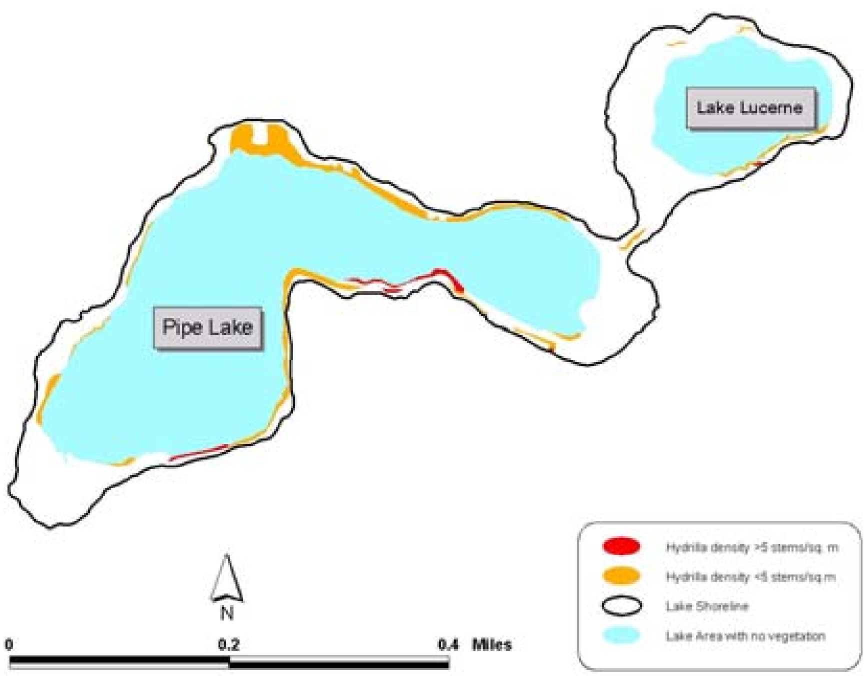

Figure2: 1996 hydrilla locations

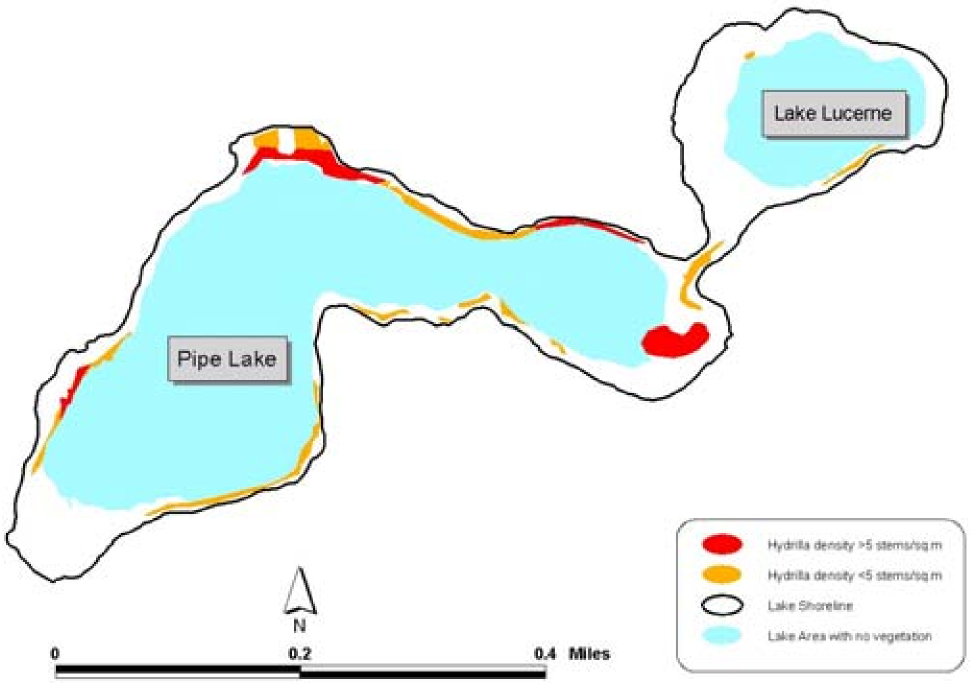

Figure3: 1997 hydrilla locations

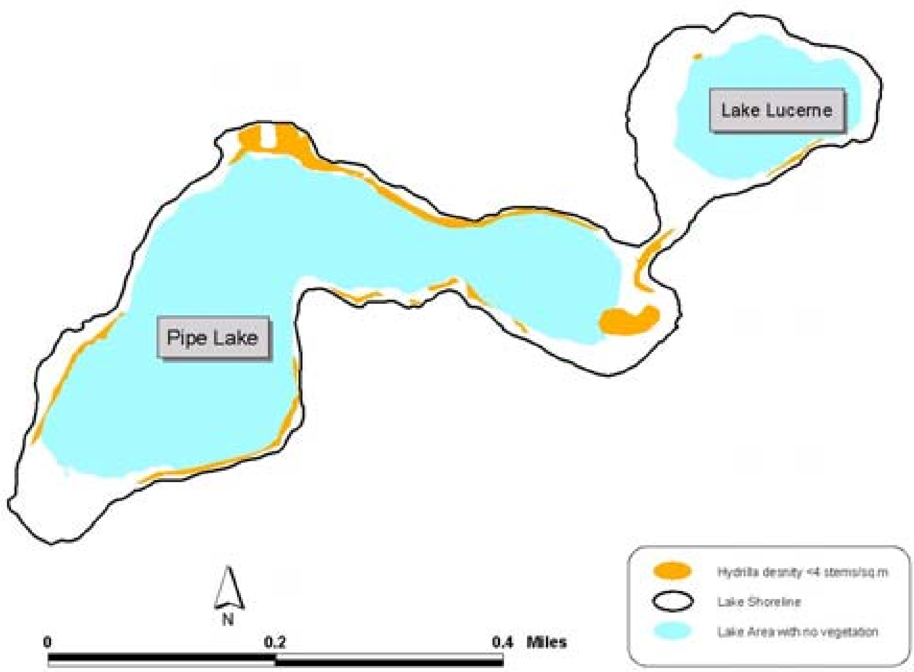

Figure 4: 1998 hydrilla locations

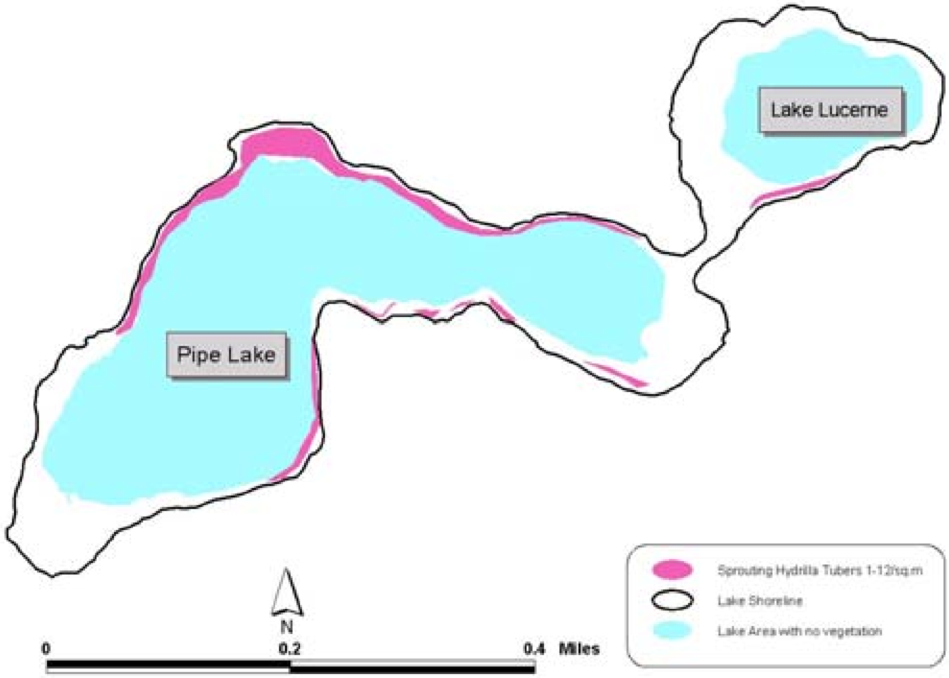

Figure5: 1999 hydrilla locations

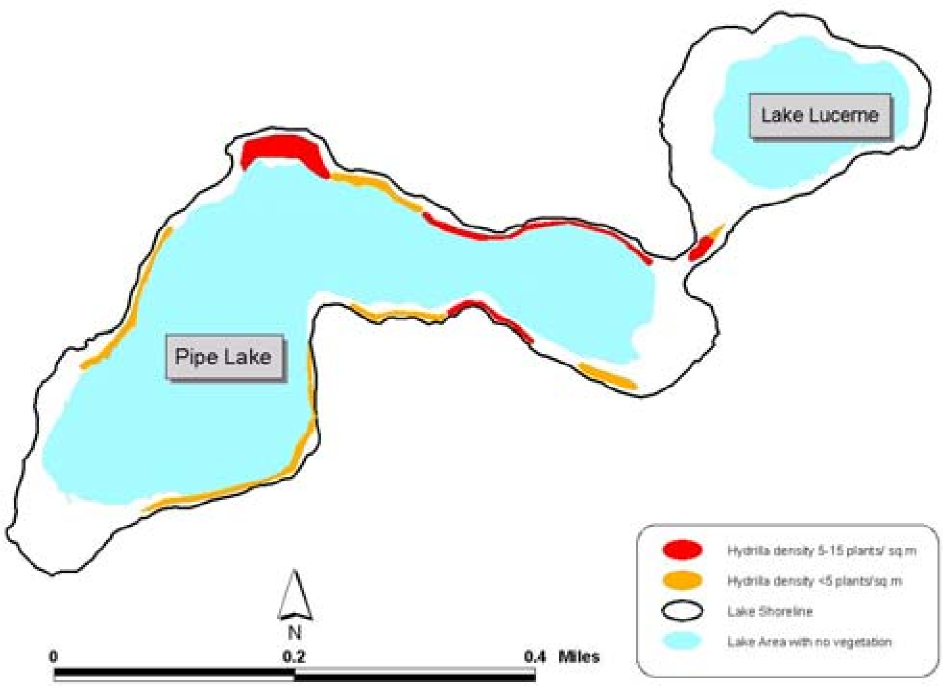

Figure 6: 2000 hydrilla locations

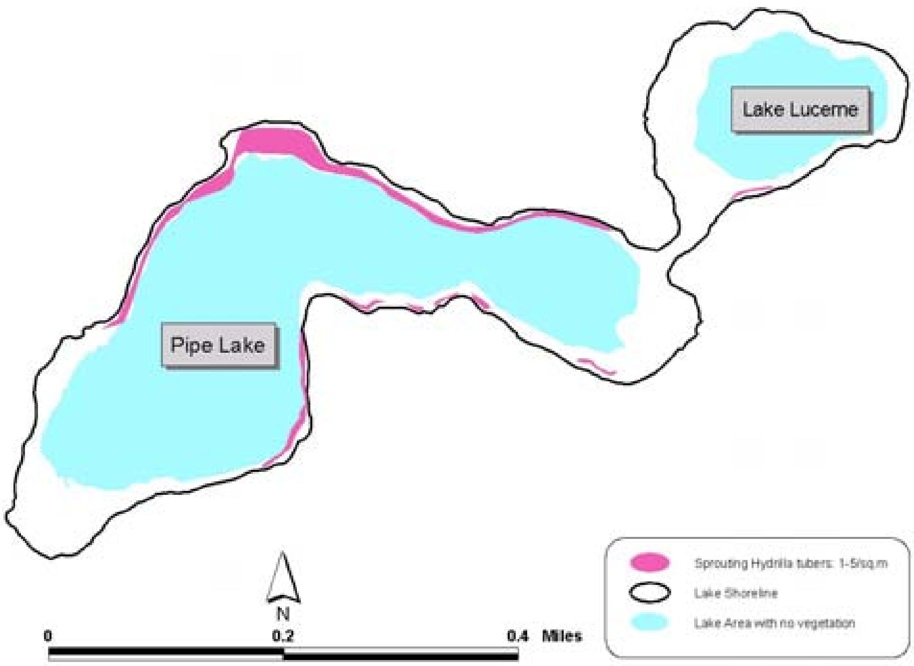

Figure 7: 2001 hydrilla locations

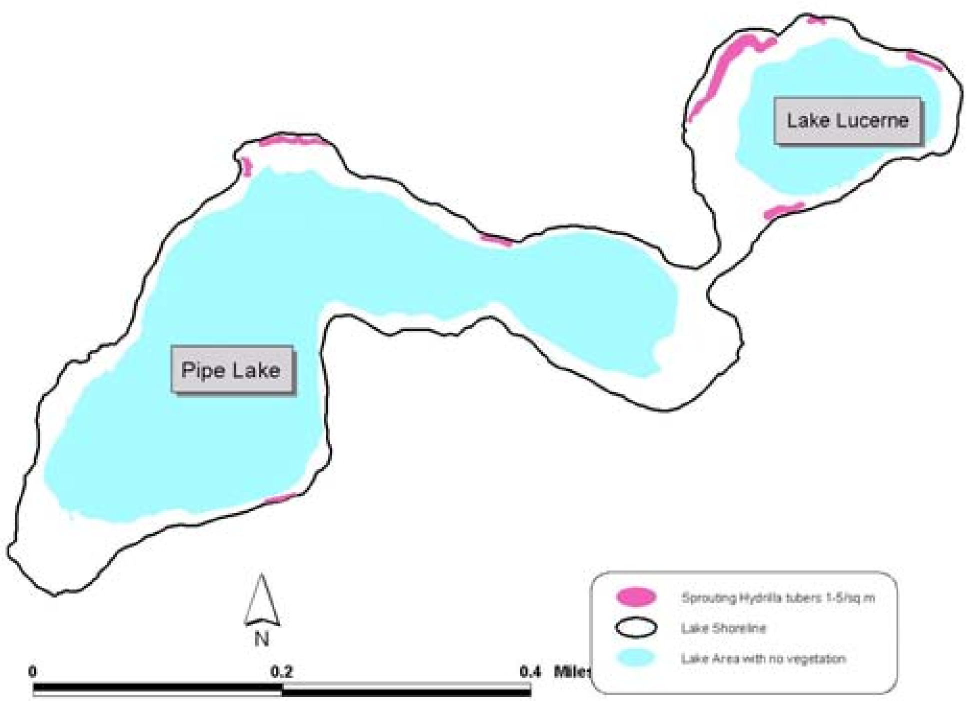

Figure 8: 2002 hydrilla locations

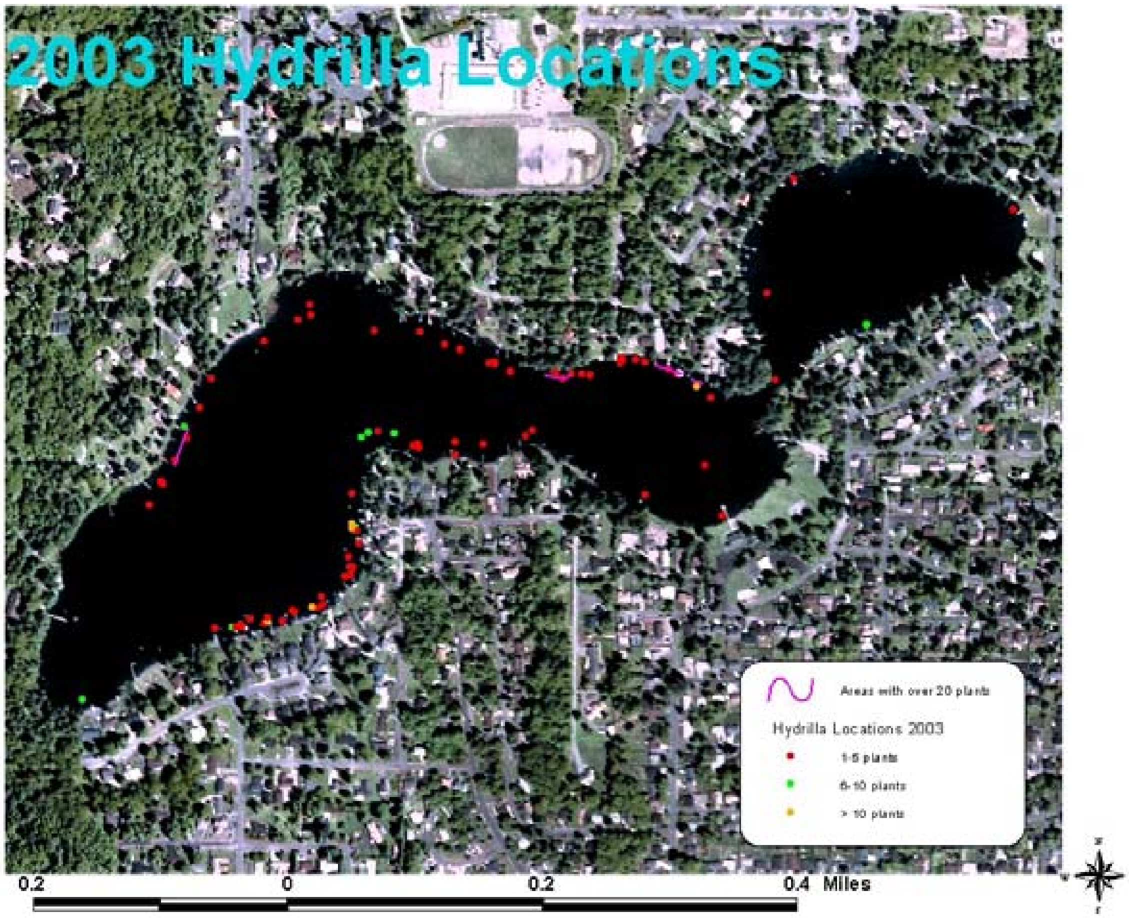

Figure 9: 2003 hydrilla locations